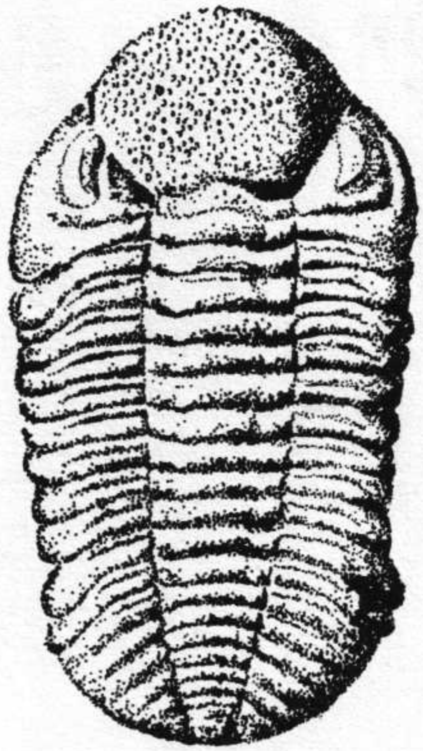
National Association of Geology Teachers – Eastern Section

FIELD GUIDEBOOK

for

The Geology of the Genesee Valley Area of Western New York



Spring Meeting
June 5–7, 1981

State University of New York, College at Brockport
Brockport, New York

PREFACE

Centered around the City of Rochester, the three field trips traverse major portions of Monroe, Livingston, and Genesee Counties. The geology of this region involves Lower Paleozoic (Ordovician to Devonian) sedimentary rocks covered by a veneer of highly dissected glacial deposits. The trips will cover:

1. The general Paleozoic bedrock history of the region;
2. Mineral collecting in the Lockport Dolomite at the Penfield Quarry;
3. Fossil collecting in the strata of the Middle Devonian Hamilton Group;
4. The glacial history of the region.

Field trips A and B use the traditional road-log format; however the format developed by Schmidt (1973) is followed for Trip C wherein the route and stops are clearly indicated on portions of topographic map sheets. This gives the reader a better overall perspective of the glacial geology and geomorphology of the region.

The trips and the meeting are due to the efforts of many people, and thanks are extended to the field trip and workshop leaders, the faculty and students of the Department of the Earth Sciences, the administrative staff of the State University College at Brockport, and to the organizational assistance of Ms. Jeanne K. Gattie.

Richard M. Liebe

Editor

GUIDEBOOK TO FIELD TRIPS

Annual Spring Meeting--National Association
of Geology Teachers--Eastern Section

June 5-7, 1981

Host: State University College at Brockport, N.Y.

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TRIP A

GENERAL GEOLOGY OF THE GENESEE VALLEY REGION IN MONROE AND GENESEE COUNTIES, NEW YORK

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INTRODUCTION

The following summary is designed to give the reader a brief introduction to the Genesee Valley region of western New York (Figure A-1). Most of the sedimentary rock nomenclature was introduced during the 1800s and early 1900s by such famous geologists as James Hall and Amadeus Grabau. The rock units mentioned herein range in age from Late Ordovician to Devonian. They are all formations and can be readily mapped. The formations are essentially horizontal, dipping only about 50' per mile to the south. Ordovician and Lower Silurian rocks are exposed in the northern part and successively younger rocks in the southern part of the region. Most of the formations can be traced along their strike from central New York into southwestern Ontario with minor lithologic changes. Pleistocene glacial deposits cover much of the region limiting most outcrop exposures to stream valleys, quarries, and roadcuts. Such exposures will be visited to familiarize the reader with the geology of the Genesee Valley region during the associated field trip. Detailed geologic descriptions of the

STRATIGRAPHIC COLUMN FOR THE GENESEE VALLEY AREA

System	Series		Group	Formation	Description	Thickness (in feet)
Devonian	Upper	Senecan	Genesee	West River	Dark gray shale with many concretions	65
				Genundewa	Blue-gray limestone	4
				Geneseo	Black shale, petroleum smell distinctive.	80±
	Middle	Erian	Hamilton	Moscow	Gray shales, fossiliferous, with some limestone layers	130
				Ludlowville	Grey limestones and shales, very fossiliferous	120
				Skaneateles	Black shales and limestones	230
				Marcellus	Black shale	30
				Onondaga	Gray fossiliferous limestones, some with abundant chert. Local members include the Edgecliff, Nedrow, Moorehouse, and Seneca.	150'
Silurian	Upper	Cayugan	Salina	Akron (Cobleskill) Bertie Camillus Syracuse Vernon	Series of waterlimes, dolostones, and shales with some halite, gypsum and anhydrite beds	550±
		Niagaran	Lockport	Lockport	Light gray massive dolostone and limestone. Local formations include the Oak Orchard, Goat Island, Gasport and DeCew	180
			Clinton	Rochester	Dark gray shale, fossiliferous layers	85
				Irondequoit	Gray shaly limestone and dolostone	18
	Lower			Williamson	Dark gray shale	6
				Sodus	Green shale with some limestone layers	12
				Reynales	Gray crystalline limestones and dolostone. Includes 2' Furnaceville Iron ore.	20
				Maplewood	Green calcareous shale	18
				Thorold (Kodak)	Gray sandstone	5
			Medina	Grimsby	Alternating thin bedded red and green mottled sandstones with some shale layers.	50±
Ordovician	Upper	Richmondian		Queenston	Brick red alternating layers of sandstone, shale, and siltstone.	40+

Figure A-1

four field-trip stops are included in the road log that starts on p. A-19. The following descriptions emphasize those units to be examined on the field-trip stops.

ORDOVICIAN SYSTEM

The Queenston Formation is the only unit of Ordovician age exposed in the region. It was named by Grabau in 1908 for a series of brick-red, thin-bedded shales and siltstones with some sandstone layers near the top. This unit is relatively unfossiliferous. Although only the upper portion of the unit is exposed in the Genesee Valley region, the Queenston Formation is more than 1000' thick and underlies much of the Lake Ontario Basin. The Queenston and the overlying Grimsby Formations represent extensive near-shore deltaic deposits which covered much of the northern portion of the Appalachian Basin during Upper Ordovician and Lower Silurian time as a consequence of the Taconic orogeny.

SILURIAN SYSTEM

The Silurian System in western New York includes a basal series of deltaic units (the Medina Group) overlain by marine sandstones, shales, and limestones deposited during an extensive marine transgression of the region (Clinton and Lockport Groups). Many of the units are visible at Stops A-1 and A-2 of the field trip. Overlying Upper Silurian rocks are poorly exposed in the entire region, and are represented by hypersaline, lagoonal deposits of the Salina Group (Figure A-1).

This report uses the Silurian statigraphy as outlined on the Silurian Correlation Chart of New York State (Rickard, 1975). Some of the terms and faunal zones used for correlation have been changed or modified. Others are undergoing extensive debate at the present time.

Much of the difficulty lies in the numerous unconformities and facies changes that occur throughout the System. Also, outcrops are sparse due to the extensive glacial cover over much of western New York.

Grimsby Formation - The Grimsby Formation (also known as the "Red Medina") was named by Williams (1919) for a series of alternating red-green mottled sandstones and shales. The base and the top portions of the formation are dominated by massive, coarse-grained sandstones containing minor siltstone and shale layers. Ripple marks and crossbedding are common in the sandstone units. The middle portion of the Grimsby Formation consists of alternating thin-bedded sandstones, shales, and siltstones. Intraformational (mud-chip pebble) conglomerates and mud cracks are common. The origin of the prominent color mottling is not clearly understood; however, the green splotches are generally thought to represent the irregular alteration of ferric iron to the ferrous state by downward percolating ground water. Fossils are rare in this formation in the Genesee Valley region, but specimens of the inarticulate brachiopod *Lingula* have been found, and some of the massive sandstones near the middle of the unit contain excellent casts of the trace fossil *Arthrophycus alleghaniensis*. The Grimsby Formation is approximately 60' thick in western New York. The section to be studied at Stop A-1 of the field trip is 55' thick (Figure A-3).

Thorold Sandstone - The Thorold Sandstone was named by Grabau (1913) for a five-foot thick massive, fine-grained, well-cemented gray sandstone. This unit forms the cap rock for the Lower Falls of the Genesee River at Rochester. Phosphatic pebbles are common near the base of the formation in the Rochester Gorge. The term Kodak Sandstone was given to this unit by Chadwick (1935) and Fisher (1966) who thought it a different unit than that exposed in the Niagara Gorge. We agree with Grasso (1973) that both

of these units represent the basal deposit of a sea transgression over the Grimsby Formation, and therefore the term Kodak is not necessary.

Maplewood Shale - The Maplewood Shale was named by Chadwick (1918) for the smooth, platy, green, in-part calcareous shale which overlies the Thorold Sandstone. A few thin limestone layers occur in the upper portion of the shale, and phosphatic pebbles are common, especially in the basal portion. Fossils are rare but impressions of brachiopods have been found. The Maplewood Shale is approximately 20' thick in the Rochester Gorge (Figure A-3), and becomes much thinner to the west where it is correlative with the Neahga Formation in the Niagara Gorge. Both formations represent quiet, offshore marine deposits.

Reynales Formation - The Reynales Formation was also named by Chadwick (1918), although James Hall (1843) first designated this unit the "Pentamerous limestone" for the numerous pentamerid brachiopods found in this unit. The Reynales Formation is a gray, crystalline limestone or dolomitic limestone with numberous shale partings. Several layers contain abundant chert. Locally, the Reynales can be divided into three members. The lower member, or Hickory Corners Limestone, is separated from the Upper Wallington Limestone Member by the well known 2'-thick Furnaceville iron ore. The furnaceville member was deposited as a fossiliferous limestone. Hematite has since replaced most of the calcium carbonate, however, samples still effervesce violently when acid is applied, indicating that much of the original carbonate mineral remains. The mechanism and time of replacement are much debated, but consensus seems to favor a penecontemporaneous alteration of the original fossiliferous limestone by iron-rich solutions from streams descending the iron-rich Taconic landmass located along the eastern margin of New York State. The Reynales Formation is generally

fossiliferous, and many different species of brachiopods have been found. Approximately 20' of the formation can be examined along the access road to Rochester Gas and Electric Company Station 4 in the Rochester Gorge (Stop A-1).

Sodus Formation - The Sodus Formation was named by Gillette (1940) for a series of interbedded green-gray shales and thin, fossiliferous limestones. One of the layers is the well-know "pearly shell limestone" long used by Ward's Natural Science Establishment as an example of a fossiliferous limestone. The Sodus Formation, as well as the overlying Williamson and Irondequoit Formations, are exposed in the east wall of the gorge, high above the access road at Stop A-1.

Williamson Shale - The Williamson Shale was named by Hartnagle (1907) for a series of dark, grayish-green, fossiliferous shales. These shales contain a few thin, dark limestone interbeds and commonly contain abundant graptolites.

Irondequoit Limestone - The Irondequoit Limestone was also named by Hartnagle (1907). It is mainly a light gray, crystalline limestone or dolomitic limestone with interbedded green shale layers. The upper limestone layers are fossiliferous, containing many types of brachiopods, horn corals, crinoid stems, and bryozoans.

Rochester Shale - The Rochester Shale was named by James Hall (1839) for a well-exposed, thick, bluish-gray shale (at the base of the Upper Falls of the Genesee River). Limestone layers are common throughout this unit which reaches a thickness of almost 100' in this region. Fossils are extremely abundant in certain calcareous units, and include fairly complete specimens of the trilobite *Dalmanites*, calyces of the cystoid *Caryocrinites*, and crinoids, a new species of which has recently been described by Brett (1980). The Rochester Shale most likely represents a relatively quiet,

well-oxygenated, offshore marine deposit as indicated by its diverse and abundant fauna.

Lockport "Formation" - The Lockport "Formation" was named by Hall (1839) for a group of dolostones and dolomitic limestones that are well-exposed along the old Erie Canal at Lockport, New York. In this summary, the Lockport "Formation" will be described as the sugary, gray, massive dolostone which is well exposed as the cap rock of the Upper Falls of the Genesee River, in road cuts along Interstate 490, and in the section to be examined at Stop A-2 of the field trip in the Penfield Quarry. However, in the Niagara Region where the Lockport "Formation" is more distinctive, Zenger (1965, 1966) has upgraded the Lockport "Formation" to a group and the earlier described "members" (including the DeCew, Gasport, Goat Island, and Oak Orchard "members") to formation status.

The Lockport Dolostone is a very resistant unit and forms the prominent east-west Niagara Escarpment that can be traced from Oneida Lake, northeast of Syracuse, to Manitoulin Island in Georgian Bay, Lake Huron. It also forms the crest of Niagara Falls. Fossils are common in portions of the dolostone but preservation is poor.

At the Penfield Quarry, operated by Dolomite Products Company, the dolostone is crushed and used in road construction. In the quarry large solution vugs occur in the upper part of the dolostone which contain a variety of well-crystallized minerals, such as fluorite, calcite, dolomite, gypsum, and celestite. These minerals are discussed in more detail on p. A-11.

Salina Group - The Salina Group is comprised of a series of waterlimes, dolostones, and shales with interbedded and economically important deposits of halite, gypsum, and anhydrite. Formation names are included in the

Stratigraphic Column (Figure A-1), but are not discussed further because the rocks of this group will not be examined on the field trip. Due to the soft or soluable nature of these formations, few good surface exposures exist in the Genesee Valley region. However, excellent waterlime outcrops are exposed in the Buffalo, Syracuse, and Utica areas, where they are well known for their spectacular, though rare eurypterid remains (Ciurca, 1973).

DEVONIAN SYSTEM

The oldest Devonian rock unit in western New York is the Middle Devonian Onondaga Limestone, which lies unconformably on eroded surfaces of various formations of the Upper Silurian Salina Group. The Onondaga Limestone represents the basal deposit of the slowly transgressing east to west sea, which was responsible for the deposition of the marine units of the Helderberg Group in eastern New York during Early Devonian time. Overlying the Onondaga Limestone are the extremely fossiliferous limestones and shales of the Hamilton Group. The overall abundance and diversity of the Hamilton Group fauna is a good indication of the presence of shallow, warm, and fairly clear epicontinental seas during Middle Devonian time in the New York State area. Upper Devonian rocks in the Genesee region are marked by basal, nearshore marine units, which are overlain by a thick series of nonmarine red sandstones, shales, and siltstones of the Catskill Delta Complex. These largely stream-deposited red beds are the youngest rocks exposed in the region and are the result of the erosion of the Acadian (Appalachian) Mountain system that was formed along the eastern margin of the United States during this time. Complex facies relationships of these deltaic deposits plus a thick overburden of glacial tills and outwash result in numerous problems for the stratigrapher attempting to

correlate rocks in the Southern Tier (Appalachian Plateau) of New York State.

Onondaga Limestone - The Onondaga Limestone was named by Hall (1859) for a fairly massive, thick series of bluish-gray limestones that can be regionally divided into members (Edgecliff, Clarence, Moorehouse, Seneca). Although the Onondaga Limestone will not be examined in detail on the field trip, it is a very well known unit. Fossils, especially solitary and colonial corals, are abundant. In addition, much of the rock has been replaced by chert, the black variety of which, flint, was well known to the Indians who came great distances to procure this material for making durable weapons and tools. The chert content also helps to make the Onondaga Limestone resistant to erosion, so that it forms a second escarpment parallel to that of the Lockport Dolostone, about 15 miles to the south. We will climb this escarpment on the way to Stop 4 of the field trip.

Marcellus Formation - The Marcellus Formation (Hall, 1839) is the basal member of the Hamilton Group and consists of thin, platy, black shales which lie directly on the Onondaga Limestone. In western New York the contact is gradational (Cooper, 1930). Fossils are common. The Marcellus Formation is locally known as the Oatka Creek Shale from a locality along the creek of the same name in Leroy. Here it is approximately 30' thick.

Skaneateles Formation - The Skaneateles Formation (Vanuxem, 1840) conformably overlies the Marcellus Formation. It is a lithologic continuation of the black shales of that formation but contains interbedded, dark gray limestones. The upper member of the Skaneateles Formation, the Levanna Shale, is a typical black shale and may be seen exposed

along the creek bed at the East Bethany fossil locality (Stop A-4).

Ludlowville Formation - The Ludlowville Formation was named by Hall (1839) for abundantly fossiliferous soft, dark gray shales. Locally it can be divided into several members. At the East Bethany fossil locality, the Centerfield, Ledyard, and Wanakah Shale Members are exposed. Corals, brachiopods, crinoid stems, and bryozoans are abundant, and a variety of other micro- and macrofossils can be found, including the trilobite, *Phacops rana* (Figure A-5 and cover).

Moscow Formation - The Moscow Formation (Hall, 1839) is another series of highly fossiliferous soft, gray shales and limestones. Although it will not be examined on the fieldtrip, the Moscow Formation is exposed in many places in western New York and its fossiliferous outcrops will be examined on Field Trip B. The abundant and diverse fossils of the Upper Hamilton Group indicate ideal, widespread, shallow, warm waters rich in organic detritus for both filter- and deposit-feeding organisms.

Genesee Group - The youngest bedrock formations in the Genesee Valley are near-shore, dark gray and black shales of the Geneseo and West River Formations. These formations are separated by the youngest marine limestone in the region, the 1'-thick Genundewa Limestone. Overlying the Genesee Group are the largely nonmarine deposits of the prograding Catskill Delta. In the Southern Tier, these deposits make up, from oldest to youngest, the Sonyea, West Falls, Canadaway, Conneaut, and Conewango Groups.

QUATERNARY SYSTEM

The glacial deposits that form a veneer over the Paleozoic rocks of the region are well exposed at Mendon Ponds, Stop A-3 of the field trip.

The deposits include materials directly deposited by the glacier and outwash deposits of streams eminating from the glacier.

MINERALS IN THE LOCKPORT FORMATION

The Lockport Formation at the Penfield Quarry of Dolomite Products Company, Penfield, New York, is a massive, dense crystalline dolostone containing cavities and fractures partially to completely filled with a variety of minerals. The rock is quarried throughout western New York and used as blocks for shoreline erosion protection, Barge Canal bank reinforcement, and crushed stone in construction and roadbed/blacktop preparation. "Dead oil", or natural asphalt, a residuum of heavy crude oil, is common in cavities, and a petroliferous odor can often be noted when the rock is fractured. No commercial production of hydrocarbons is known, however, small pockets of natural gas are frequently encountered during construction projects in the Monroe County area.

In the Rochester region, the Lockport Formation is about 180 feet thick, 80 feet of which are exposed in the Penfield Quarry. Fossil corals and their molds are common in some layers, but are difficult to remove from the rock matrix. Many are sites of mineral crystallization. Cavities produced by the solution of fossils, as well as primary evaporite nodules (anhydrite/gypsum), and other relatively soluble zones (e.g., more calcareous portions of the dolostone) have provided the setting for the mineralization of a variety of well-formed crystals. Thin cross-cutting veins, possibly related to stylolites, and joints and other fractures can be found completely filled with secondary minerals. The following minerals may be found at the Penfield Quarry:

Anhydrite ($CaSO_4$). Light blue crystalline masses filling cavities. May

envelop other minerals and be partially altered to white crystalline gypsum.

Calcite ($CaCO_3$). Pale yellow, well-formed scalenohedral ("dog-tooth") crystals up to 7 cm long in cavities. Surfaces of dolomite crystals are commonly coated with minute crystals of calcite.

Celestite ($SrSO_4$). Light blue to white prismatic crystals up to 10 cm in length, found in cavities; some cavities filled with coarse, massive crystals. Commonly enveloped by granular gypsum or a single clear crystal of gypsum (selenite). Colorless, clear crystals similar in habit to celestite may be barite.

Dolomite ($CaMg(CO_3)_2$). White rhombohedral crystals lining solution cavities with faces up to 1 cm across. Most abundant mineral in quarry; interesting in that commonly acts as a base for minute crystals of pyrite, marcasite, sphalerite, and calcite.

Fluorite (CaF_2). Isolated cubic crystals up to several centimeters along edges. Occurs as transparent light blue, yellow, green, and purple crystals.

Galena (PbS). Most common in veins as a metallic gray mineral. Exhibits cubic cleavage.

Gypsum ($CaSO_4 \cdot 2H_2O$). Fine-grained, white, massive cavity filling. Large crystals of transparent selenite common. Examine carefully for included celestite.

Marcasite (FeS_2). Minute (1-3 mm) blade-shaped prisms with a dark metallic luster. Most common as scattered groups on dolomite crystals.

Pyrite (FeS_2). Minute (1 mm), tarnished, brassy pyritohedrons, octahedrons, and cubes on dolomite crystals.

Quartz (SiO_2). Drusy minute crystals lining cavities.

<u>Sphalerite ((Zn,Fe)S)</u>. Light to dark brown, yellow brown, and red brown equidimensional crystals up to 10 mm in size in cavities. Vitreous to resinous in appearance. Also as thin veins.

Bassett and Kinsland (1973) reviewed the characteristics of the "Mississippi Valley" type of mineral association similar to that found in the Lockport Formation. The proposed origins for such deposits are: (1) original deposition; (2) original scattered deposition with modification by regional metamorphism; (3) original scattered deposition with modification by circulating ground water moving up; (4) original scattered deposition with modification by circulation ground water moving down; and (5) deposition from fluids of igneous derivation with hydrothermal or gas transport either with volatile aid or as a metal-rich vapor.

Pratt (1949) evaluated three possible modes of origin of the mineral assemblages of the Lockport Formation: (1) secondary introduction by magmatic hydrothermal solutions; (2) introduction by meteoric water; or (3) redistribution and concentration of indigenous materials via ground water. He favored an origin by ground-water concentration of indigenous minerals.

Extensive studies of primary carbonate mineralogy and dolomitization processes support the indigenous character of the elements in the minerals. Milliman (1973) summarized the initial composition of carbonate sediments. Magnesium, strontium, iron, barium, zinc, and lead have been identified as significant components in the hard parts of various marine organisms. Large amounts of these elements are common also in the soft parts of organisms. Celestite and gypsum are common in settings thought to represent the process of dolomite formation in recent environments. Some fluorine may be incorporated into sediments as fluorite.

The redistribution of these elements into their present location and

form in the Lockport Formation probably started soon after deposition. Chemical, thermal, pressure, and pore-fluid changes acting on the indigenous carbonate sediments over millions of years of burial and uplift logically could have produced the assemblage observed today.

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SELECTED BIBLIOGRAPHY

Bassett, W. A. and Kinsland, G. L., 1973, Mineral collecting at Penfield Quarry, p. H1-H9, in *New York State Geological Association Guidebook, 45th Annual Meeting*, Brockport, New York, (P. C. Hewitt, editor).

Bolton, T. G., 1957, Silurian stratigraphy and paleontology of the Niagara Escarpment in Ontario: *Geol. Surv. Canada Memoir 289*, 145 p.

Bowen, A. P., Sutton, R. G., McAlester, A. L., and Rhoads, D. C., 1970, Upper Devonian deltaic environments, p. B1-B11, in *New York State Geological Association Guidebook, 42nd Annual Meeting*, Cortland, New York, (W. G. Heaslip, editor).

Brett, C. E., 1980, *Paracolocrinus*, a new inadurate crinoid genus from the Rochester Shale (Silurian, Wenlockian) of New York: *J. Paleontology*, v. 54, p. 913-922.

Buehler, E. J., 1966, The Hamilton Group in western New York, p. 44-45, in *New York State Geological Association Guidebook, 38th Annual Meeting*, Buffalo, New York, (E. J. Buehler, editor).

Chadwick, G. H., 1918, Stratigraphy of the New York Clinton: *Geol. Soc. Am. Bull.*, v. 29, p. 327-368.

Chadwick, G. H., 1935, Kodak Sandstone: *Am. Assoc. Pet. Geol. Bull.*, v. 19, no. 5, p. 702.

Ciurca, S. J., Jr., 1973, Eurypterid horizons and the stratigraphy of the Upper Silurian and ? Lower Devonian of western New York State, p. D1-D14, in *New York State Geological Association Guidebook, 45th Annual Meeting*, Brockport, New York (P. C. Hewitt, editor).

Cooper, G. A., 1930, Stratigraphy of the Hamilton Group of New York: *Amer. Jour. Science*, v. 19, p. 116-134, 214-236.

de Witt, W. and Colton, G. W., 1978, Physical stratigraphy of the Genesee Formation (Devonian) in western and central New York: *U.S. Geol. Survey Prof. Paper 1032-A*.

Fisher, D. W., 1966, Pre-Clinton rocks of the Niagara frontier - A synopsis, p. 1-9, in *New York State Geological Association Guidebook, 38th Annual Meeting*, Buffalo, New York (E. J. Buehler, editor).

Gillette, Tracy, 1940, Geology of the Clyde and Sodus Bay quadrangles, New York: *New York State Mus. Bull. 320*, 179 p.

Gillette, Tracy, 1947, The Clinton of western and central New York: *New York State Mus. Bull. 341*, 191 p.

Grabau, A. W., 1908, A revised classification of the North American Silurian: *Science*, n.s., v. 27, p. 622-623.

Grabau, A. W., 1913, Early Paleozoic delta deposits of North America: *Geol. Soc. Am. Bull.*, v. 24, p. 399-538.

Grasso, T. X., 1973, A Comparison of environments - The Middle Devonian Hamilton Group in the Genesee Valley, p. B1-B27, in *New York State Geological Association Guidebook, 45th Annual Meeting,* Brockport, New York (P. C. Hewitt, editor).

Grasso, T. X., 1973, Stratigraphy of the Genesee Gorge at Rochester, p. I1-I22, in *New York State Geological Association Guidebook, 45th Annual Meeting*, Brockport, New York (P. C. Hewitt, editor).

Guidebook for field trips in western New York, 1956, 121 p., in *New York State Geological Association Guidebook, 28th Annual Meeting,* Rochester, New York.

Hall, James, 1839, Third annual report of the fourth geological district of the State of New York: *N.Y. Geol. Surv. Ann. Report, no. 3*, p. 287-339.

Hall, James, 1843, *Geology of New York. Part 4, Comprising the Survey of the Fourth Geologic District,* Albany, New York, 525 p.

Hartnagel, C. A., 1907, Geologic map of the Rochester and Ontario Beach quadrangles: *New York State Mus. Bull. 114*, 35 p.

Hunter, R. E., 1970, Facies of iron sedimentation in the Clinton Group, p. 101-121, in *Studies of Appalachian Geology: Central and Southern*, New York, John Wiley and Sons, Inc. (Fisher, G. W., *et al.* eds.).

Kilgour, W. J., 1966, Middle Silurian Clinton relationships of western New York and Ontario, p. 10-17, in *New York State Geological Association Guidebook, 38th Annual Meeting,* Buffalo, New York (E. J. Buehler, editor).

Milliman, J. D., 1973, *Marine Carbonates*, New York, Springer-Verlag, 375 p.

Oliver, W. A., 1966, Bois Blanc and Onondaga Formations in western New York and adjacent Ontario, p. 32-43, in *New York State Geological Association Guidebook, 38th Annual Meeting*, Buffalo, New York (E. J. Buehler, editor).

Platt, R. M. 1949, *Lead and zinc occurrence in the Lockport Dolomite of New York State*, M.S. Thesis, Geological Sciences Library, University of Rochester.

Rickard, L. V., 1975, Correlation of the Silurian and Devonian rocks in New York State, *New York State Museum and Science Service, Map and Chart Series*, no. 24.

Vanuxem, Lardner, 1840, Fourth annual report of the geological survey of the third district: *New York Geol. Surv. Ann. Report, no. 4*, p. 355-383.

Williams, M. Y., 1919, The Silurian geology and faunas of Ontario Peninsula and Manitoulin and adjacent islands: *Geol. Surv. Canada, Memoir 3,* 195 p.

Zenger, D. H., 1965, Stratigraphy of the Lockport Formation (Middle Silurian) in New York State: *New York State Mus. Bull. 404*, 210 p.

Zenger, D. H., 1966, The Lockport Formation in western New York, p. 19-23, in *New York State Geological Association Guidebook, 38th Annual Meeting*, Buffalo, New York (E. J. Buehler, editor).

Generalized Map of the Greater Rochester Area and localities visited on field trip A, ES/NAGT June 6, 1981.

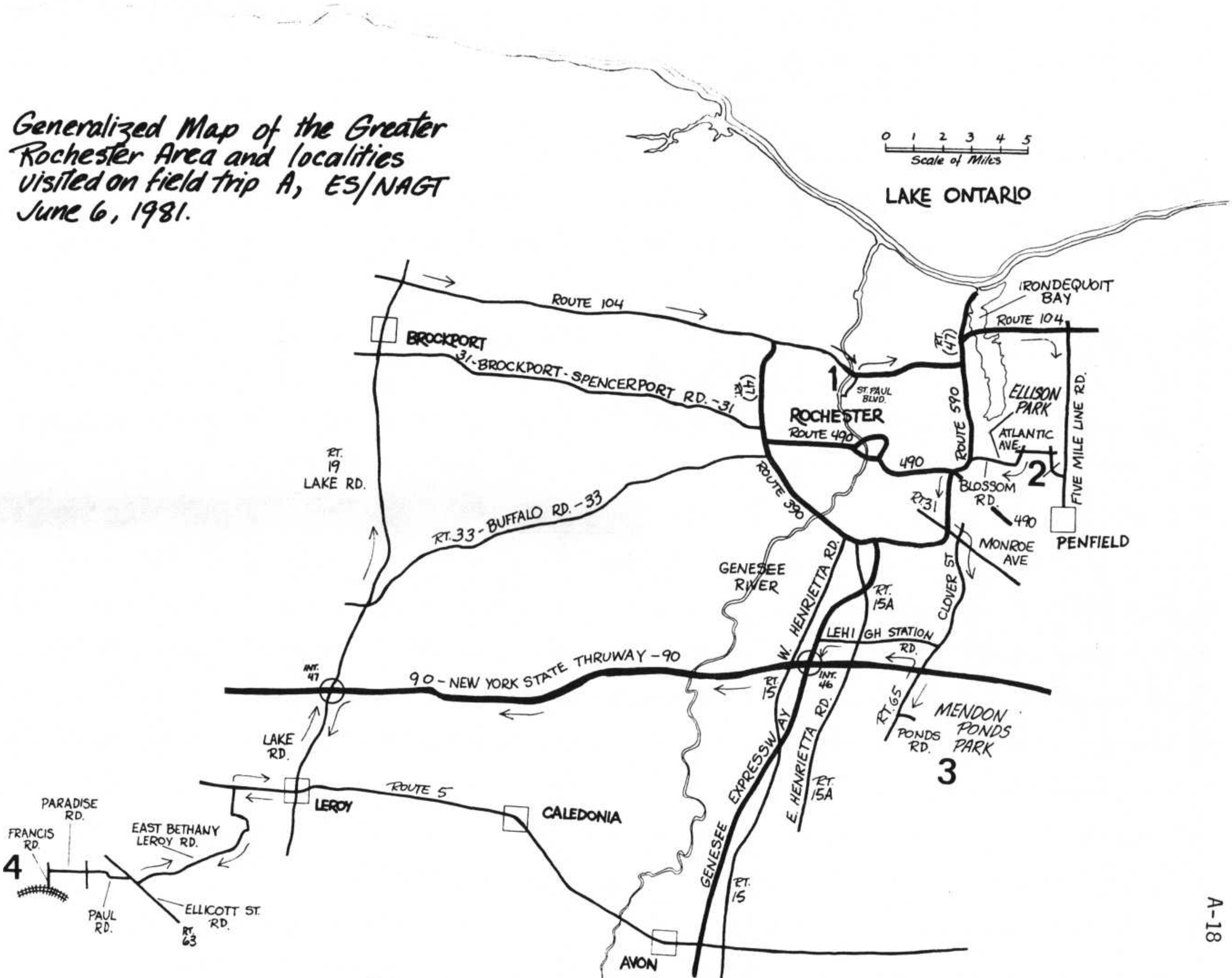
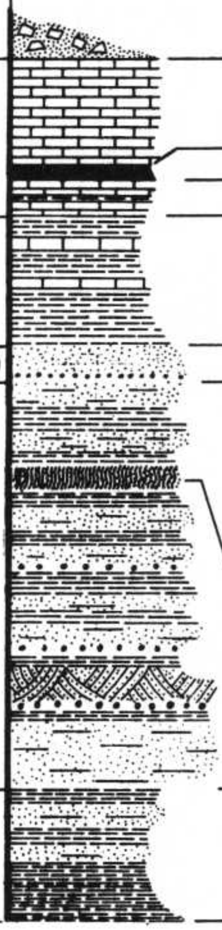


FIG A-2

ROAD LOG - FIELD TRIP A

Total Miles	Miles From Last Point	Route Description
0.0		Starting point - traffic light corner of Main Street (NY 19) and State Street, Village of Brockport. Proceed north on NY 19.
0.2	0.2	Cross Barge Canal.
0.4	0.2	Traffic light at intersection with East-West Avenues. Proceed straight (north).
1.5	1.1	Traffic light at intersection with NY 104. Turn right (east) on NY 104.
3.0	1.5	Cobblestone house on right. Cobbles obtained from Lake Ontario beach gravel.
3.5	0.5	Intersection NY 260. Proceed straight.
4.0	0.5	View of lake plain to north. NY 104 follows (old) beach ridge of glacial Lake Iroquois. Plain visible for next several miles.
5.5	1.5	Cross Salmon Creek.
6.2	0.7	Gravel pits to south in glacial outwash.
8.6	2.4	Intersection NY 259. Proceed straight.
9.2	0.6	Cobblestone house on south side.
9.8	0.6	House of Grimsby (Medina) Sandstone on south side.
10.6	0.8	Landfill on north side for fly ash from coal generated Kodak power plant.
10.8	0.2	Intersection Manitou Road (NY 261). Proceed straight.
13.7	2.9	Intersection Long Pond Road. Proceed straight.
13.9	0.2	Former church constructed with Grimsby Sandstone.
14.8	0.9	Intersection NY 390. Proceed straight.
15.6	0.8	Intersection Mt. Read Boulevard. Kodak Park complex begins here and continues for 2 miles.

Diagrams are taken from The Field Guidebook for the Geology of the Genesee Valley Area of Western New York (1981), published by the National Association of Geology Teachers - Eastern Section.



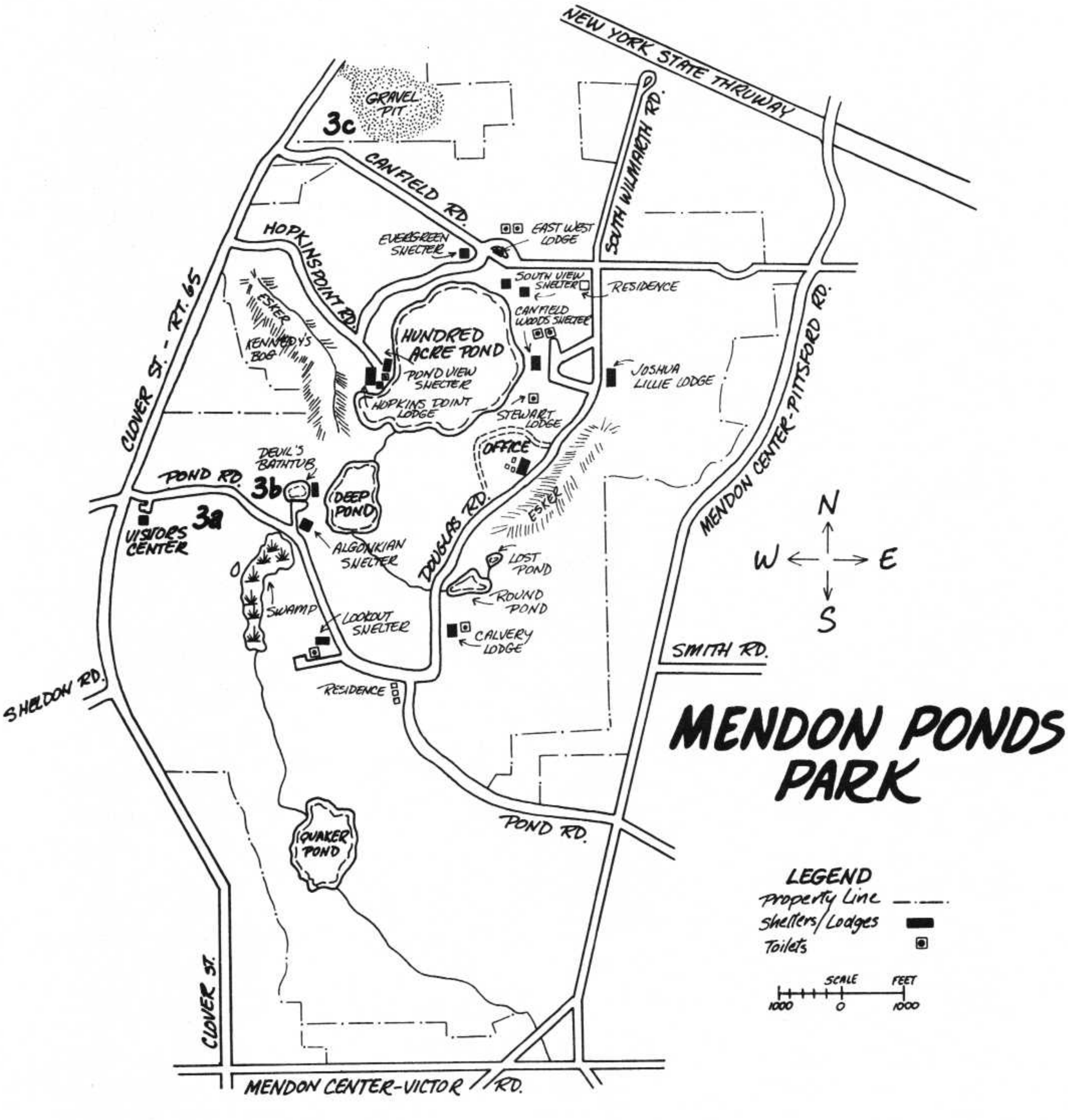
Period	Formation	Rock Description
Quaternary		Glacial till
Silurian	Reynales	Light gray crystalline limestone. Thin beds with shale partings. some beds contain abundant brachiopods (Pentamerus).
		Furnaceville iron ore member
		Brewer Dock limestone member
	Maplewood	Platy, green calcareous shale. Few thin limestone layers.
	Thorold(Kodak)	Gray sandstone. Phosphate pebbles at base.
	Grimsby	Alternating beds of red sandstone and shale. Prominent red-gray mottling. Some layers show prominent bioturbation. Mudcracks, ripple marks, and flat-pebble conglomerates common. Some sandstone units cross-bedded. = bioturbated zone
Ord.	Queenston	Alternating beds of red shale, siltstone, and sandstone. Mud cracks common. Scale 1" = 25'

Fig. A-3

Cross-section of Paleozoic units in the Rochester Gorge along the access road to RGE Power Station #4, Lower Falls of the Genesee River, Rochester, N.Y. (Stop #A-1)

16.1	0.5	Coal piles for Kodak power plant.
17.1	1.0	Main area, Kodak Park.
17.8	0.7	Cross Veteran's Memorial Bridge at beginning of Keeler Street Expressway.
18.0	0.2	Intersection St. Paul Street. Turn right (south).
18.4	0.4	Traffic light at intersection with Norton Street - Seth Green Drive. Turn right (west) on Seth Green Drive.
		<u>STOP #1 - Rochester Gorge, Lower Falls Area</u> Below the infamous Driving Park Bridge, the oldest rock units exposed in the greater Rochester area will be examined. The Genesee River, in its northward flow to Lake Ontario, has carved a post-glacial gorge almost 200 feet deep at this point, after being diverted from its pre-glacial outlet through Irondequoit Bay. See text and text Figures A-1 and A-3 for description of the Upper Ordovician to Middle Silurian rocks exposed in the gorge along the access road to Station #4, an electrical power generating station run by the Rochester Gas and Electric Corporation. Permission must be secured before bringing groups here. (1 hour)
18.4		Return to intersection of St. Paul Street with Seth Green Drive and Norton Street. Proceed straight (east) on Norton Street.
18.9	0.5	Silver Stadium, home of the International League Rochester Red Wings, on north side.
19.0	0.1	Intersection Seneca Street. Turn left (north).
19.4	0.4	Intersection NY Route 104 (Keeler Street Expressway). Turn right (east) and enter the expressway.
22.4	3.0	Intersection with NY 590/47. Stay left on NY 104.
23.8	1.4	Irondequoit Bay. This was the mouth of the pre-glacial Genesee River. Now it is closed off by a barrier beach at the northern end of the bay. A very popular place for sailboats.
26.8	3.0	Intersection with Five Mile Line Road. Turn right (south).

27.6	0.8	Intersection with NY 404 (old NY 104). Proceed straight.
31.3	3.7	Intersection Atlantic Avenue. Proceed straight.
32.1	0.8	Intersection Whalen Road. Turn right (west).
32.4	0.3	Entrance to Penfield Quarry on north side.
		STOP #2 - Dolomite Products Co. Quarry This locality is famous as a collecting site for museum quality minerals. The minerals here are found in the Lockport Formation of Silurian age. For more detailed information on the occurrence and origin of these minerals and the Lockport Formation, refer to the text associated with the field trip log. The quarry is not open to individual collectors or groups without special prior permission of the owner, Mr. John Odenbach, Jr. (90 minutes)
32.4		Leave quarry by turning right (west) on Whalen Rd. Proceed to Atlantic Avenue.
33.3	0.9	Turn left (west) on Atlantic Avenue.
34.4	1.1	Turn left (south) on Blossom Road.
35.1	0.7	Entrance to Ellison Park. This will be our lunch/rest stop. (45 minutes)
36.5	1.4	Continue west on Blossom Road to intersection NY 590/47. Turn left (south) on 590.
37.2	0.7	"Can-of-Worms". Stay on 590.
39.4	2.2	Take NY 31 East (second exit). This is Monroe Avenue.
40.2	0.8	Turn right (south) on Clover Street (NY 65s). Proceed straight.
41.6	1.4	Erie Canal Lock and Canal Park.
41.9	0.3	Cross NY 252 (Jefferson Road). Proceed straight. For the next few miles drumlins can be seen on both sides of the road.
45.1	3.2	Cross Thruway. Note collection of erratics around house to right. Proceed straight.



NEW YORK STATE THRUWAY
GRAVEL PIT
3c
CANFIELD RD.
SOUTH WILMARTH RD.
EAST WEST LODGE
EVERGREEN SHELTER
HOPKINS POINT RD.
SOUTH VIEW SHELTER
RESIDENCE
CANFIELD WOODS SHELTER
HUNDRED ACRE POND
ESKER
KENNEDY'S BOG
JOSHUA LILLIE LODGE
POND VIEW SHELTER
HOPKINS POINT LODGE
STEWART LODGE
MENDON CENTER-PITTSFORD RD.
CLOVER ST. - RT. 65
OFFICE
DEVIL'S BATHTUB
POND RD.
3b
DEEP POND
ESKER
3a
VISITORS CENTER
ALGONKIAN SHELTER
DOUGLAS RD.
N
W
E
S
LOST POND
ROUND POND
SWAMP
LOOKOUT SHELTER
CALVERY LODGE
SMITH RD.
SHELDON RD.
RESIDENCE
MENDON PONDS PARK
POND RD.
QUAKER POND
LEGEND
Property Line
shelters/Lodges
Toilets
SCALE FEET
1000 0 1000
CLOVER ST.
MENDON CENTER-VICTOR RD.

FIG. A-4

46.9	1.8	Third and main (south) entrance to Mendon Ponds Park (Pond Road). Turn left (east). Proceed to visitor's center.
		<u>STOP #3 - Mendon Ponds Park</u> We will make three stops in the park (Figure A-4). The first of these is to view the glacial exhibit and model for the park in the Visitor's Center. The second stop will be at the top of an esker fan overlooking the Devil's Bathtub, a kettle-hole lake. The third stop will be along the north edge of the park where we will view the huge Clover Sand and Gravel Company pit cut in an esker. Between stops you will be passing through a very picturesque glacial landscape. The ice age features of this park are described in more detail in the pamphlet printed by the Interpretive Service of the County of Monroe (to be provided). (90 minutes).
51.2	4.3	Leave park by the north exit (Canfield Road). Turn right (north) on NY 65 (Clover Street).
51.6	0.4	Entrance to Clover Sand and Gravel Company quarry. Time permitting we may briefly stop to observe the stratified sand and gravel deposits which occassionally exhibit large-scale crossbedding. Proceed north on NY 65.
53.0	1.4	Turn left (west) on NY 253, Lehigh Station Road. We will cross several N-S drumlinoid structures in the next few miles. Proceed straight.
57.4	4.4	Turn left (south) on Interstate 390.
58.1	0.7	Enter Thruway (Interstate 90). Head west toward Buffalo.
62.2	4.1	Cross the Genesee River.
74.5	12.3	Take Exit 47 (Leroy). Proceed on Interstate 490.
75.1	0.6	Turn right at NY 19 exit. Proceed toward Leroy.
77.0	1.9	Climb Onondaga escarpment. The rocks exposed on both sides of the road here are the Upper Silurian Salina Group.
78.0	1.0	Gravel pit to right (west). Gravel contains many pebbles, cobbles, and boulders of Onondaga limestone and chert.

79.9	1.9	Intersection NY 5 (Town of Leroy). Turn right (west).
80.8	0.9	Turn left (south) on East Bethany-Leroy Road.
87.2	6.4	Turn right (north west) on NY 63. Town of East Bethany.
87.4	0.2	Turn obliquely left (west) on Paul Road (sign is not legible).
89.0	1.6	Cross Center Road. Proceed straight (Paul Road becomes Paradise Road).
90.5	1.5	Road ends. Turn left (south on Francis Road).
91.1	0.6	Road ends at closed-off railroad bridge.

STOP #4 - East Bethany Fossil Locality
This locality is famous in western New York as a collecting site for Middle Devonian (Hamilton Group) fossils. The section to be visited extends approximately one-half mile east of the abandoned railroad bridge over the tracks of the Delaware, Lackawanna and Western Railroad. The tracks are presently operative so do not ignore the sound of approaching trains. The stratigraphic section here is as follows:

Ludlowville Formation	
Tichenor Limestone	(1 ft.±)
Wanakah Shale	(15 ft.)
Ledyard Shale	(88 ft.)
Centerfield Shale	(2-4 ft.)
Skaneateles Formation	
Levanna Shale	(unknown thickness)

Although most of the section contains at least some fossils, we will essentially confine our collecting to the Centerfield Shale member of the Ludlowville Formation in an adjacent stream bed about 30 feet below the railroad outcrops. Here the ground surface is comprised almost exclusively of fossils weatered from the Centerfield Shale and washed clean of matrix. Crinoid stems, bryozoa, brachiopods, and horn corals are particularly abundant. Microfossils are common and include formainifera, ostracods, echinoderm plates and spines, and immature specimens of the macrofauna (and "cinderites"!). Figure 5-A shows some of the fossils that can be found at the locality. Other typical

Hamilton Group fossils are included in Figures 4-15 of Field Trip B. Time permitting the hillside slopes near the bridge will also be examined. Primarily of interest here are body segments of the trilobite *Phacops*.

In the section along the railroad track the strata dip gently to the west at a maximum of 5 degrees. This is a result of the Clarendon-Linden flexure (monocline) which displaces strata in the subsurface more than 100 feet. This north-south lineament has been the focus of gas exploration in western New York for many years, and further exploration is planned this fall north of this area. (75 minutes)

106.1	15.2	Retrace route to Thruway entrance. Turn left (north) on NY 19.
109.1	3.0	Cross NY 33 (Buffalo Road). Proceed toward Brockport.
117.7	8.6	Lockport Escarpment. On a clearday you can see "forever", or at least Lake Ontario.
120.0	2.3	Village of Brockport, the campus of the State University College at Brockport, and end of the field trip.

Common Fossils from the Hamilton Group
(Middle Devonian), Western New York

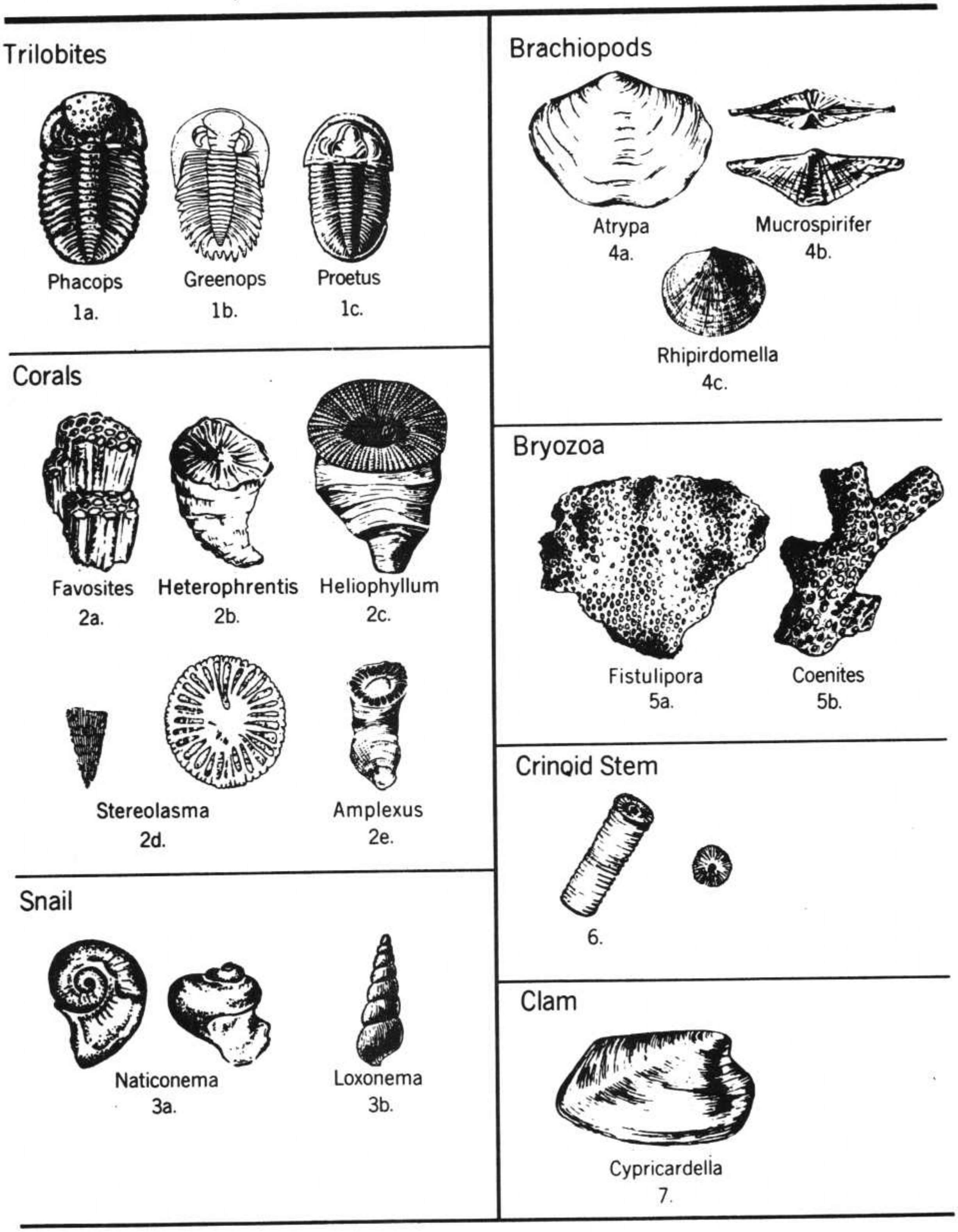


Figure A-5

Stratigraphy, Paleontology and Paleoecology of the Upper Hamilton Group (Middle Devonian), in the Genesee Valley, Livingston County

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INTRODUCTION

The Devonian System in New York State varies from carbonates below (Ulsterian and lowest Erian Series) to coarse continental clastics at the top (Chatauquan Series), and represents a westward migrating deltaic complex built during Middle and Late Devonian time.

This deltaic complex, the Catskill Delta, is today represented by a wedge of sedimentary rock that thickens and coarsens eastward. The clastic wedge is pierced at several horizons by relatively thin, but geographically widespread, lithologically distinct units that do not change facies as rapidly as the rocks above or below. Serving as time planes, these key beds subdivide the clastic wedge into a number of major time-stratigraphic units.

Three carbonate keybeds in the lower portion of the wedge serve to subdivide the lowest time-stratigraphic unit, the Hamilton Group (Middle Devonian), into four formations; which are from oldest to youngest, the Marcellus, Skaneatles, Ludlowville and Moscow Formations.

The Middle Devonian Hamilton Group of New York State is structurally simple and highly fossiliferous, thereby lending itself to detailed stratigraphic, paleontologic, and paleo-ecologic studies. In the Genesee Valley it consists of approximately 515 feet of black shales, dark gray shales, and calcareous gray shales lying above the Onondaga Limestone and below the Leicester Pyrite (Table 1). The Hamilton thins westward to 285 feet on Lake Erie and thickens eastward to 650 feet on Canandaigua Lake, 1000 feet in the Tully Valley, 1,650 feet in the Unadilla Valley, 1,950 feet in the Sus-quehanna Valley and 2,285 feet near Richmondville. The thicknesses as given above and the stratigraphic relations of the Hamilton Group of New York as now understood were first clarified by Cooper's classic papers (1930, 1933).

The Hamilton rocks in the Genesee Valley region dip to the southeast at approximately 40 feet per mile.

TABLE 1

AGE	GROUP	FORMATION	MEMBER	APPROXIMATE THICKNESS IN FEET
Late Devonian	Other Upper Devonian Units			
	Genesee	West River Shale		65
		Genundewa Limestone		5
		Penn Yan Shale		30
		Geneseo Black Shale*		50
	Leicester Pyrite*			0-.2
Middle Devonian	Hamilton	Moscow	Windom Shale*	47
			Kashong Shale*	85
			Menteth Limestone*	1
			Deep Run Shale*	8
			Tichenor Limestone*	2
		Ludlowville	Jaycox Shale*	11
			Wanakah Shale*	35
			Ledyard Shale*	57
			Centerfield Limestone*	10
		Skaneateles	Levanna Black Shale*	230
			Stafford Limestone	2
		Marcellus	Oatka Creek Black Shale	30
	Onondaga Limestone			145
	Silurian Formations			

* = units to be examined

HAMILTON SECTION IN THE GENESEE VALLEY

In the Genesee Valley, the Hamilton is composed to two facies. The lower, (encompassing the Marcellus and Skaneateles Formations and the Ledyard Member of the Ludlowville Formation), is a fissile black and dark gray shale facies with few argillaceous limestone and limey lenses of the anaerobic distal basin, carrying a low diversity primarily pelagic and epipelagic fauna. Above this facies is one representing a subtidal, off-shore distal platform - outer stable shelf environment of gray calcareous shales and gray shales with numerous limestone beds, argillaceous limestone layers and limey bands. It is characterized by a high diversity benthonic fauna.

STRATIGRAPHY

Ludlowville Formation (Figure B-1)

The Ludlowville Formation was named by Hall (1839) for the rocks on Cayuga Lake between the Centerfield Limestone and what he called the "Encrinal Limestone" (Tichenor-Portland Point Limestones). In the Genesee Valley, it consists of 113-115 feet of black and dark gray shales succeeded by calcareous gray shale with thin argillaceous limestone beds and occasional thin, shell coquinites. Cooper (1930) subdivided the Ludlowville into 5 members in ascending order, Centerfield, Ledyard, Wanakah, Tichenor and Deep Run. Recent, detailed stratigraphic, work by Baird (1979) indicates that the Tichenor and Deep Run are western correlatives of the basal member of the Moscow Formation, the Portland Point Limestone, and therefore should be included in the Moscow Formation. Further, the base of the Tichenor is a regional paraconformity, truncating successively older upper Ludlowville units westward (erosional overstep westward). Cooper (1930) included the 11 feet of richly fossiliferous calcareous shales below the Tichenor, in the Genesee Valley, within his Tichenor Member. Grasso (1973) regarded these shales as uppermost Wanakah. Baird (1979) erected a new name, the Jaycox Shale Member, for this interval of strata which is followed herein as shown on Figure B-1.

STRATIGRAPHIC SECTION LUDLOWVILLE FORMATION GENESEE VALLEY

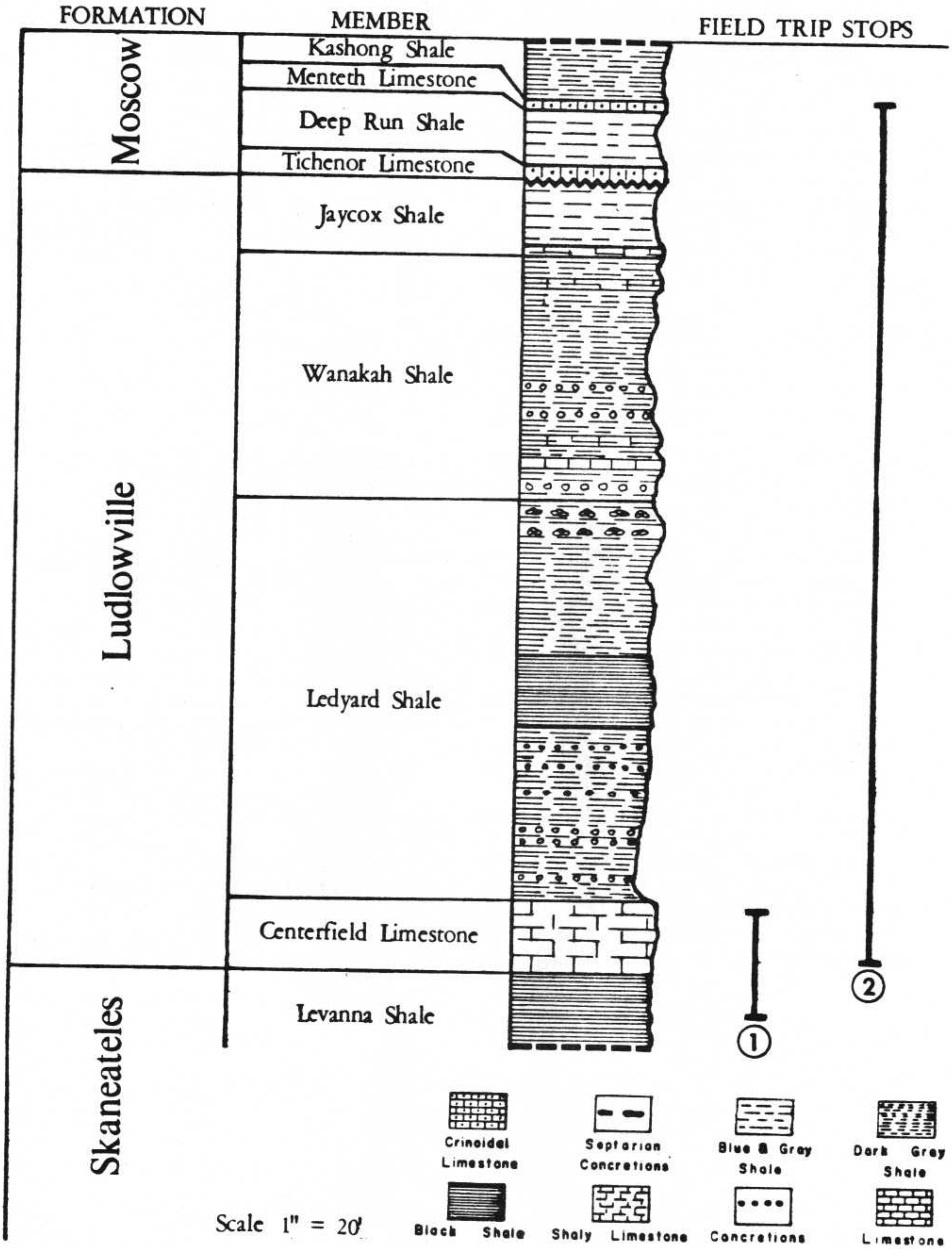


Figure B-1

Centerfield Limestone Member (Stops 1, 2)

The name Centerfield was first proposed by Clarke (1903) for the thin limestones on Schaffer Creek, 1 mile north of the settlement of Centerfield. In the Genesee Valley it is approximately 10 feet of calcareous shale interbedded with thin limestone and argillaceous (marly) limestone containing an abundant and moderately diversified fauna dominated by microphagous carnivore rugose and tabulate corals. Large epifaunal filter feeding brachiopods are conspicuous along with some epifaunal crawling or ploughing collectors such as trilobites.

Ledyard Shale Member (Stop 2)

The Ledyard Shale comprises 57 feet of dark gray, calcareous shale with interbedded black shale. Black shale is most conspicuous in the middle part of the unit (Figure B-1). Calcareous non-septarian concretions less than 1 foot in diameter are abundant at certain horizons throughout the unit. Larger septarian concretions are found toward the top of the Ledyard.

First named by Cooper (1930), the Ledyard yields a low-diversity fauna indicative of relatively high paleoenvironmental stress. Deposit-feeding worms, small epifaunal filter feeding brachiopods without a functional pedicle in the adult stage (reclined), along with epipelagic brachiopods dominate the assemblage. Trilobites occur throughout the Ledyard, while a thin zone of gastropods is found about 3 feet below the top of the unit.

Wanakah Shale Member (Stop 2)

The name Wanakah was first used by Grabau (1917). Cooper (1930) re-defined it and as such the Wanakah comprises the succeeding 35 feet of dark gray to gray shales containing a number of thin limestone and argillaceous limestone bands lying above the Ledyard in the Genesee Valley. Small non-septarian calcareous concretions occur in the lower part of the Wanakah.

The Wanakah is very fossiliferous especially in the lower and upper parts of the unit. The fauna is dominated by large, epifaunal, filter feeding, brachiopods, but corals, bryozoans, crinoids, bivalves and trilobites are also common at certain horizons.

Jaycox Shale Member (Stop 2)

Previously included by Cooper (1930) in the overlying Tichenor Limestone Member and by Grasso (1973) in the underlying Wanakah Shale Member, Baird (1979) has proposed a new name for this interval, the Jaycox Shale. The Jaycox begins with a 1 foot, muddy, limestone bed succeeded by 11 feet of light gray, calcareous, shale. The type section is the south branch of Jaycox Creek. The Jaycox Shale is distinguished from the underlying Wanakah by its lighter color, greater carbonate content and distinctive fauna. The upper contact with the Tichenor is sharp and represents a regional paraconformity.

This member is by far the most fossiliferous unit in the Hamilton Group of the Genesee Valley. It contains a high diversity fauna of brachiopods, corals, bryozoans, bivalves, gastropods, trilobites, echinoderm columnals and holdfasts, and some lithistid demosponges.

Moscow Formation (Figure B-2)

The term Moscow was first introduced by Hall (1839) from exposures on Little Beards Creek and others in the vicinity of the village of Leicester, originally Moscow until the end of World War I and the Bolshevik Revolution! As recognized by Hall the formation included all the strata from the base of the "Encrinal" (Tichenor) to the Tully Limestone or Geneseo Black Shale. Cooper (1930) discovered that the "Encrinal" (Tichenor) in the Genesee Valley was different from the "Encrinal" in the Cayuga Lake region, which correlated with the stratigraphically higher Menteth Limestone of the Genesee Valley. Therefore, Cooper's Moscow begins with the Menteth. Baird's (1979) studies indicates that the Moscow-Ludlowville contact should be drawn at the base of Tichenor Limestone Member.

In the Genesee Valley, the Moscow Formation consists of 145 feet of blue-gray to dark gray shales intercalated with numerous limestone and argillaceous limestone bands and concretionary layers.

Tichenor Limestone Member (Stop 2)

The name Tichenor was first introduced by Clarke (1903) for a 1 foot bed of crinoidal or "Encrinal Limestone" exposed in Tichenor Point Ravine on Canandaigua Lake.

STRATIGRAPHIC SECTION MOSCOW FORMATION GENESEE VALLEY

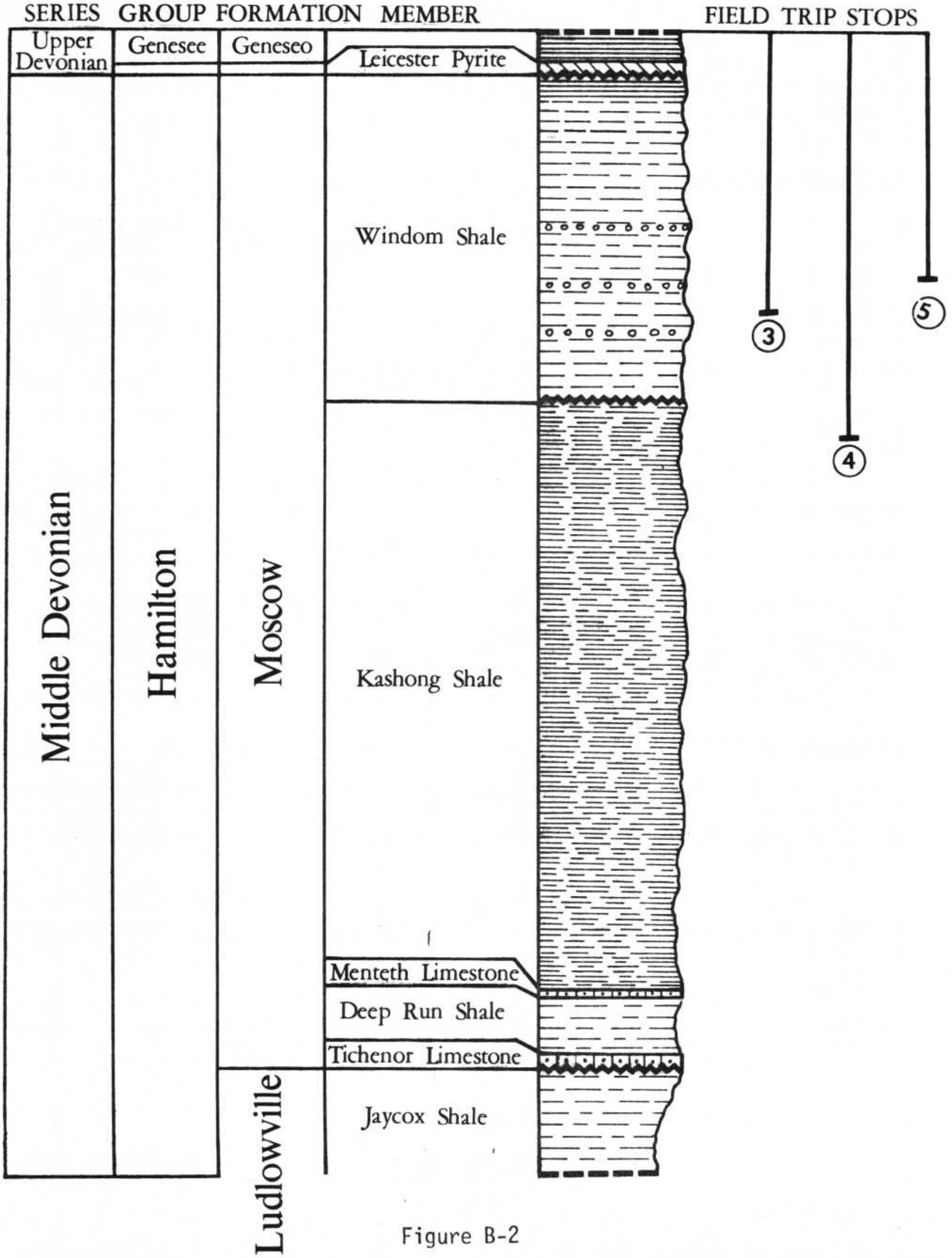


Figure B-2

The Tichenor, in the Genesee Valley is a thin (3 feet) blue-gray, calcarenitic, hard limestone, with limonite staining on exposed surfaces due to weathering of its contained pyrite. The upper 1 foot or so, consists of thin limestones and interbedded thin limestone and calcareous shale.

The fauna of the Tichenor is highly diverse, consisting mostly of large tabulate and rugose corals, bryozoans, brachiopods, crinoids, and lithistid demosponges (Baird, 1979).

Deep Run Member (Stop 2)

The 8 feet of brittle, blue-gray shale and shaley mudstone lying between the Tichenor and Menteth Limestones was named Deep Run by Cooper (1930).

The Deep Run contains a low diversity fauna (Figure B-3) of brachiopods, bivalves, bryozoans, worm trails, and large specimens of the trilobite *Phacops rana*.

Menteth Limestone Member (Stop 2)

The Menteth was named by Clarke and Luther (1904) and consists of 1 foot of dense, gray, crinoidal, heavily bioturbated limestone with irregularly distributed terrigenous mud due to bioturbation (Baird, 1979).

The faunal content of this unit resembles that of the underlying Deep Run, being essentially of low diversity - crinoid stems, worm trails, trilobite fragments and especially the feeding trail of the ichnofossil *Taonurus* (*Zoophycus*).

Kashong Shale Member (Stop 4)

The Kashong consists of soft, blue-gray, fossiliferous shale with calcareous concretions and argillaceous limestone beds in the upper part. Named by Cooper (1930) he assigned a thickness of 85 feet to this unit in the Genesee Valley.

The upper contact of the Kashong is an erosional discontinuity marked by reworked Kashong fossils, numerous phosphatic pebbles and steinkerns (Baird, 1978).

The Kashong fauna in moderately diverse containing an assemblage of brachiopods, bivalves, bryozoans, crinoids, trilobites and a few specimens of the phyllocarid *Echinocaris*.

The Kashong is poorly exposed in the Genesee Valley, only the lower and upper several feet being readily accessable. The uppermost part will be the only portion of the Kashong examined on the field trip.

Windom Shale Member (Stops 3, 4, 5)

Grabau (1917) named the Windom from exposures on Smokes Creek at Windom near Orchard Park. In the area of study, the Windom includes approximately 47 feet of soft gray shales and thin interbedded argillaceous limestone. Calcareous concretions are especially abundant from 20 feet to 35 feet above the base of the unit.

The Windom is bounded above and below by regional discontinuities. The lower contact above the phosphatic zone of Baird (1978) is marked by the Ambocoelia - Chonetes (Devonochonetes) Zone characteristic of the lowermost Windom. The upper contact occurs at the base of the Leicester Pyrite, the westward equivalent of the Upper Devonian Tully Limestone.

The Windom carries a high diversity assemblage of brachiopods, bryozoa, corals, trilobites, bivalves, crinoids, gastropods, worm trails and in the upper part, the graptolite *Dictyonema*.

In addition, two currious pyritic assemblages occur in the Windom in the Genesee Valley, although four have been mapped and studied in the Windom of Western New York by Okita (1980).

BENTHIC COMMUNITIES AND PALEOENVIRONMENTS

In the last several years paleoecological interpretations have been greatly strengthened through the community analysis approach. This concept pivots around the idea that combinations of certain abundant species define a community. This defination closely approaches that of Peterson (1913) and Molander (1930, quoted in Newell and others, 1959, p. 198) and subsequently utilized by Zeigler (1965); Zeigler, Cocks, and Ranbach (1968); Bretsky (1970); Sutton, Bowen, and McAlester (1970); Bowen, Rhoads, and McAlester (1974); Titus and Cameron (1976) and McGhee (1976).

Some of the communites named and delineated herein may include the habitat community of Newell and others (ref. cit.). An inherent problem in all this is the imperfection of the fossil record. Johnson (1964) presents tables illustrating that soft bodied organisms, almost never known as fossils, constitute anywhere from 33% to 99% of the total living community. From fossils we can make some inferences about past communities, but we must keep in mind they are not the same as the total community.

Other approaches to paleoenvironmental studies used in concert with, and as part of, community analyses would be trophic structure and paleoautecology or general adaptive type. The relative proportions of filter and deposit feeding organisms (trophic structure) has been used with some success in several cases (Brower, et al. 1978, Driscoll, 1969; Grasso, 1973, 1978, Grasso and Wolff, 1977, Scott, 1976). However, Stanton and Dodd (1976) from benthic community studies in San Francisco Bay and the Pliocene of the Kettlemen Hills, Califormia, conclude that feeding type proportions in the fossil community are not always indicative of original environmental parameters.

Paleoautecology of the shelly fauna can be important in arriving at general paleoenvironmental conditions. Lophoporate filter feeders such as articulate brachiopods were probably all stenohaline save for some rhynchonellids and lingulids which were more tolerant of fluctuating salinities. In contrast, many bivalves may be euryhaline. Life habits (adaptive types) of various species of bivalves and brachiopods (Bowen, Rhoads, and McAlester, 1974; McGhee, 1976) through taxonomic analogy with modern taxa and functional morphology can yield significant data.

The communities and paleoenvironments outlined below are based on data such as species combinations, abundance, life habits (adaptive type), and trophic structure in addition to the physical criteria of gross lithology and sedimentary structures. Most of the fossils mentioned below are illustrated on Figures B-4 to B-15.

Heliophyllum - Atrypa Community

This community restricted to the Centerfield Member, is a moderate to high diversity assemblage dominated by micro-carnivores, rugose and tabulate corals, filter feeding bryozoans and crinoids, and epifaunal filter feeding brachipods. Corals dominate the assemblage in the limestone beds, especially large colonies of tabulate corals and nearly approaches a biostrome, closely parelleling those described by Oliver (1951). The argillaceous limestone or marly limestone interbeds contain higher proportions of filter feeders with nearly a total absence of colonial corals.

This community is dominated by the rugose corals *Heliophyllum halli*, *Amplexiphyllum hamiltoniae*, *Heterophrentis simplex* and *Cystiphylloides americanum*. The colonial rugose coral *Eridophyllum americanum* is also present. Tabulate corals include *Aulopora* sp., *Favosites alpenensis* and *Favosites hamiltoniae*. Fenestellid bryozoans, and crinoid columnals are also very common. Large epifaunal filter feeders are represented by the unattached (reclined) filter feeders *Atrypa reticularis*, *Mucrospirifer mucronatus* and *Megastrophia concava*. Attached or pedunculate filter feeders are represented by *Mediospirifer audaculus* and *Rhipidomella vanuxemi*, although these large filter feeders are less abundant than the reclined species. Crawling or ploughing epifaunal collectors are represented by the trilobite *Phacops rana* and the snail *Platyceras*, although this species may have been coprophagous on crinoids.

The Centerfield, nearly a true limestone and dominated by microcarnivors, attests to a brief period of decreased influx of terrigenous clastics (as their feeding mechanisms would have clogged) relative to the shales of the Levanna below and the Ledyard above. Relatively low energy conditions must have prevailed as indicated by many of the corals being in living position, the abundance of brachipods without a function pedicle in the adult stage, that would have been easily toppled, and the lack of high energy features such as cross bedding and fine grained nature of the rock. Slight increases in the influx of argillaceous or clayey material accounts for the marly limestone deposition with its commesurate increase in the abundance of brachiopods and decreased frequency of corals.

In total, the Centerfield represents deposition in a shallow, relatively clear, normal marine environment below effective wavebase, as indicated by the abundant and diversified fauna, especially corals.

Kramers (1970) suggests an offshore bar or submarine shoal became activated in Centerfield time in Central New York and may have acted as a sediment trap allowing carbonate deposition to take place westward in the basin.

Chonetes - Ambocoelia Community

The soft, dark gray and black shales of the Ledyard Member represents this community. Gradually deteriorating environmental conditions for microcarnivores, large epifaunal filter feeders and high level filter feeders such as crinoids and bryozoans beginning in late Centerfield time culminated in their complete removal by Ledyard time.

The Chonetes - Ambocoelia Community is characterized by a mixed assemblage of pelagic and benthonic forms, many being crawling and ploughing collectors.

The benthonic assemblage is dominated by small epifaunal reclined brachiopods. The deep incurved pedicle valves of *Ambocoelia* and *Chonetes* and the spinose hinge line of *Chonetes* seem to make these taxa ideally suited for life on soft substrates as these characteristics aid in keeping the commissure free of mud by a "snow-shoe" effect.

Pelagic representatives include the epiplanktonic, thin shelled, filter feeding brachiopod *Leiorhynchus* along with the cephalopod *Orthoceras*, the nektonic carnivore. A subassemblage characterized by large numbers of *Leiorhynchus* may be recognized in the true black shale interval of the middle Ledyard Member.

Infaunal deposit feeding worms are extremely abundant in this community as indicated by the numerous pyritized worm trails, weathered to limonite. Other infaunal deposit feeders found in this community, although less frequently, are the small, smooth bivalves *Nucula, Paleoneilo,* and *Nuculites triqueter*.

Vagrant ploughing and crawling collectors are very common, chief amoung them being the trilobites *Phacops rana* and to a lesser extent *Greenops boothi*. Also in this tropic group would be the gastropods *Mourlonia itys*, *Naticonema lineata*, *Paleozygopleura hamiltoniae*, and *Bembexia sulcomarginata* probably grazing on algal mats and other submarine plants.

The Ambocoelia - Chonetes Community dwelt in a quiet-water, marine habitat, at moderate depths. A soft bottom, high in organic detritus supplying nutrients for deposit feeders is envisioned. The sediment-water interface was less oxygenated relative to that in Centerfield time and occasionally devoid of free oxygen especially during deposition of the *Leiorhynchus* rich black shale interval. In summation, this community inhabitated a moderate to high stressed environment as indicated by the low faunal diversity and trophic structure (see Figure B-3).

FAUNAL ANALYSIS
LUDLOWVILLE-LOWER MOSCOW FORMATION
JAYCOX RUN

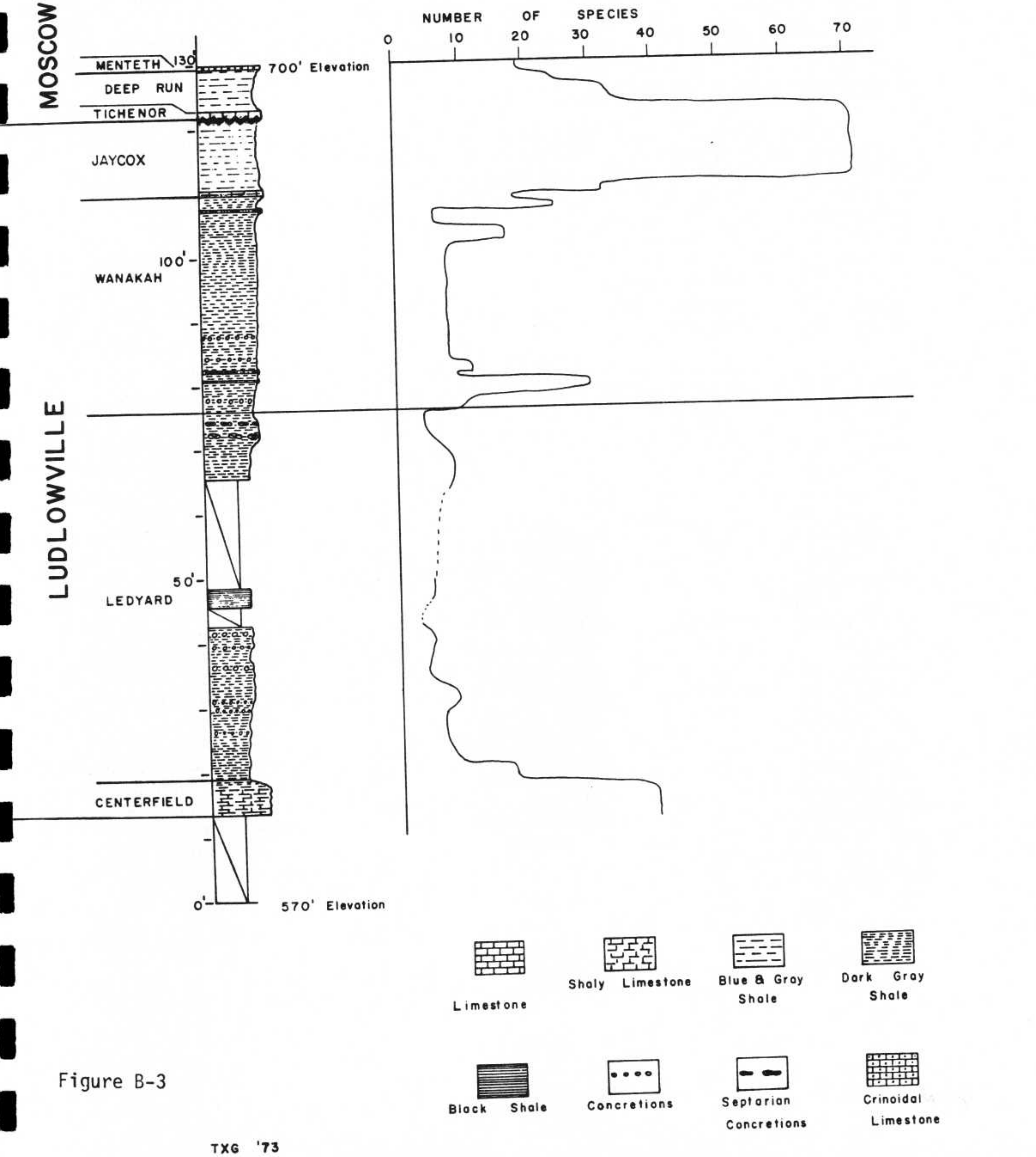


Figure B-3

TXG '73

In somewhat modified form, with the addition of *Rhipidomella*, *Mucrospirifer*, and a few solitary rugose corals, this community is present in the lower Windom Shale Member of the Moscow Formation, probably reflective of better oxygenated conditions in the lower Windom.

Mucrospirifer - Ambocoelia Community

Confined to the Wanakah Member this community of moderate to high faunal diversity is dominated by brachiopods especially *Mucrospirifer mucronatus*. Several subassemblages can be recognized within this unit based on trophic structure and diversity. These faunal changes probably relect subtle vagaries in the physical parameters of turbidity, oxygen levels, sites for larval attachment, firmness of the substrate and availability of organic detritus in the sediment or overlying water column. In general adaptive strategies were aimed at survival on soft substrates.

The brachiopod *Mucrospirifer mucronatus* dominates the community although occurring more frequently in certain intervals than in others. Its wide alate hinge, preventing the organism from sinking, and reclined habit makes it well adapted to soft bottom, low energy environments. *Ambocoelia* and *Chonetes* are commonly found with *Mucrospirifer* or together in strata immediately above and below those containing just *Mucrospirifer*. *Productella* (*Strophalosia*) is infrequently found in the lowest portion of the Wanakah. Attached brachiopods are fairly common and represented by *Athyris spiriferoides*, *Atrypa reticularis*, *Rhipidomella*, *Mediospirifer audaculus* and *Spinocyrtia granulosa*.

Epibyssate bivalves such as *Pterinopecten* are present as well as the endobyssate bivalve *Modiomorpha subalata* (Stanley, 1972), especially in a limey mudstone bed capping a small waterfalls about 8 feet above the base of the Wanakah Member.

Tabulate corals such as *Pleurodictyum americanum* and *Aulopora* are common in the lowest four feet. *Stereolasma rectum*, the solitary small rugose coral is common at various horizons, apparently the larvae attaching to the shells of other invertebrates (Bray, 1971). *Pleurodictyum* commonly attached to the shells of *Paleozygopleura*. These corals may have been tolerant of more turbid water or grew at times of low clastic sediment influx.

Numerous bryozoans and crinoid stems occur sporadically.

Infaunal deposit feeders include the bivalves *Paleoneilo* and *Nuculites* as well as numerous worm trails, especially those of *Zoophycus* (*Taonurus*).

The gastropods *Nauticonema*, *Paleozygopleura* and *Bellerophon* along with *Phacops rana* are the common crawling collectors and ploughers.

Leiorhynchus, the pteropod *Styliolina fissurella*, and orthoconic cephalopods occur commonly on a few bedding planes.

In general, more favorable conditions prevailed during Wanakah times due to higher amounts of dissolved oxygen. A shallow to moderate water depth, normal marine, low to moderately stressed, low energy, soft, muddy, substrate environment is suggested. Abundant organic material was available for both filter and deposit feeders and to a lesser extent microcarnivores.

Cypricardella - Heliophyllum confluens Community

The basal 1 foot of muddy limestone and succeeding 11 feet of calcareous shale of the Jaycox Member contains the most diverse and distinctive assemblage in the upper Hamilton Group of the Genesee Valley.

The basal muddy limestone caps the top of the largest falls in Jaycox Run (south branch) at an elevation of 710 feet and is characterized by large epibyssate and endobyssate bivalves, infaunal deposit feeding bivalves, gastropods and brachiopods. Epibyssates are represented by *Pseudaviculopecten princeps*, *Pterinopecten* and *Mytilarca;* endobyssates by *Cypricardella bellistriata*, *Actinopteria decussata*, *Modiomorpha mytiloides*, *M. concentrica*, and *Goniophora hamiltoniae*, infaunal deposit feeders by *Paleoneilo*, gastropods by *Mourlonia* and *N aticonema* and brachiopods by *Stropheodonta demissa*, *Mucrospirifer mucronatus* and *Mediospirifer audaculus*.

The calcareous shales above are extremely diverse yielding most of the common Hamilton forms. Many corals are abundant and *Heliophyllum halli var. confluens* is particularly unusual. The attached brachiopods *Pentameralla*, *Meristella*, *Parazyga*, and *Elytha fimbriata* are common along with many others. Sponges, bryozoans, bivalves, gastropods, annelid trails, trilobites, crinoids and blastoids are all present.

The Cypricardella - Heliophyllum Community inhabited shallow well oxygenated, moderately agitated water near effective wave base. Clastic sediment influx was sporadic allowing for thin coral biostromes to develop from time to time.

Favosites Community

Found in the Tichenor Limestone, this community is dominated by large tabulate and rugose corals. Bryozoans, attached

brachiopods, gastropods and many crinoids complete the assemblage. Environmental conditions closely paralleled those that prevailed during Centerfield time with less amounts of clay-sized detritus.

Crinoidal - Phacops Community

This community is characterized by crinoid stems, bryozoans, the reclined brachiopod *Tropidoleptus*, worm trails, *Phacops rana* (often large), and few endobyssate and epibyssate clams. It is confined to the Deep Run Shale and dwelt in shallow, well oxygenated, quiet water of moderate stress. Soft substrates containing abundant organic debris for deposit feeders and collectors is inferred. The absence of abundant corals indicates a return to turbid water allowing filter feeders to thrive.

Taonurus Community

The heavily bioturbated Menteth Limestone contains the *Taonurus* (*Zoophycus*) Community. Large crinoid stems, and fragments of the large trilobite *Dipleura dekayi* as well as *Phacops rana* are conspicuous.

A relatively high energy, moderate to high stressed environment prevailed during Menteth time.

Tropidoleptus - Bivalve Community

This assemblage is present in the poorly exposed Kashong Shale in the Genesee Valley. Only the upper few feet will be examined (Stop 4).

The reclined brachiopod *Tropidoleptus carinatus* dominates but other forms adapted to soft bottoms are also conspicuous such as, *Chonetes* and *Mucrospirifer*. Endobyssate bivalves are common beginning with *Orthonota undulata*, and followed by *Cypricardella bellistriata*, *Modiomorpha*, and *Grammysia bisulcata*. A few epibyssates are found such as *Actinopteria* and *Pseudaviculopecten*. The phyllocarid *Echinocaris* and *Dipleura dekayi* are less common elements in the community. This moderate diversity community inhabited soft substrates in shallow water of low energy, reminiscent of the Ledyard but containing higher levels of dissolved oxygen.

Mucrospirifer - Coralline Community

This community is recognized by its large number of brachiopods, corals, bryozoans, bivalves, and trilobites. It occurs in the upper 30 or so feet of the Windom in the Genesee Valley. Most of the forms present here also occur in the Wanakah Shale Member of the Ludlowville Formation. Reclined brachiopods are abundant such as *Mucrospirifer*, *Chonetes*, *Ambocoelia*, and the large strophomenid *Megastrophia concava*. The attached types are represented by *Athyris spiriferoides*, *Atrypa reticularis*, *Spinatrypa spinosa*, *Spinocyrtia marcyi*, and *S. granulosa*. Corals are quite frequent in occurrence occassionally forming thin biostromes and represented by *Stereolasma rectum*, *Heliophyllum halli*, *Amplexyphyllum hamiltoniae*, *Pleurodictyum americanum*, and *Favosites*. The trilobites *Phacops rana* and *Greenops boothi* are common. The crinoid *Dolatocrinus* is present as well as the graptolite *Dictyonema*. Worm trails are common.

The Mucrospirifer - Coralline Community contains the highest diversity in the Moscow Formation of the Genesee Valley. It dwelt in well oxygenated, shallow water, of low energy. An abundant food supply was available in the water as well as the substrate. At times of low clastic influx, corals thrived forming coral beds or biostromes.

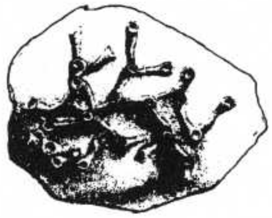
Leiorhynchus Community

The uppermost 2-5 feet of the Windom is a dark or black shale containing the epiplanktonic, thin shelled, brachiopod *Leiorhynchus*. This signifies that near the end of Windom time, the opulence of middle Windom time just described came swiftly to an end. Deepening water and low levels of dissolved oxygen prevented most benthonic forms from becoming established.

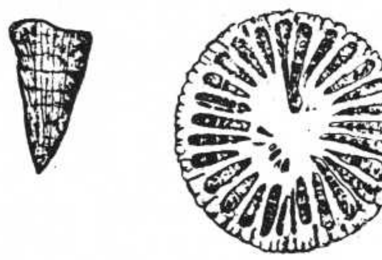
ACKNOWLEDGMENTS

The author would like to thank Richard D. Hamell of Monroe Community College who aided in the field work and compiled the figures of fossils and Catherine S. O'Connell, also of Monroe Community College, who laid out and drafted the stratigraphic sections and locality map.

Heliophyllum halli

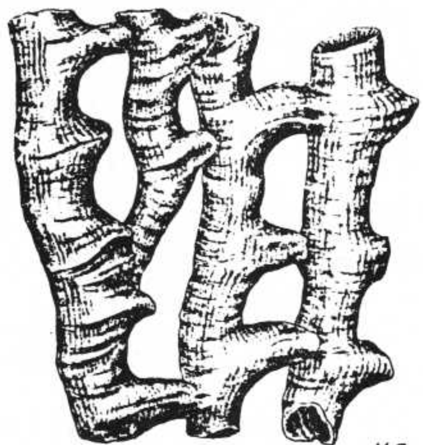


Aulopora sp.

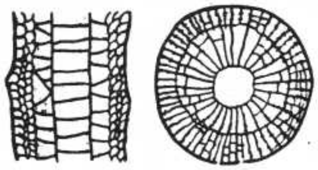


X2

Stereolasma rectum

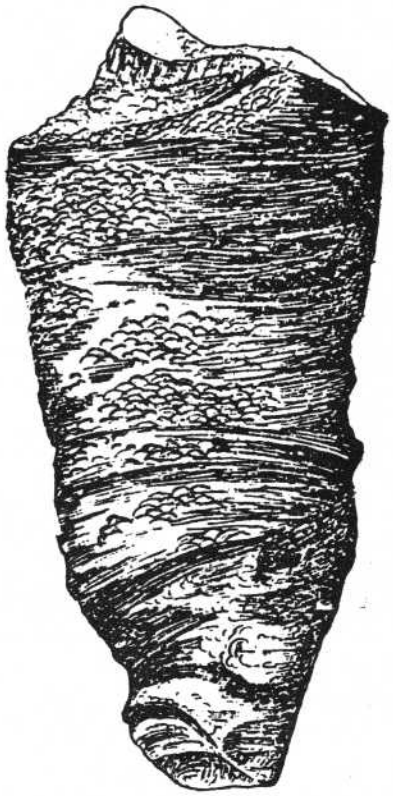


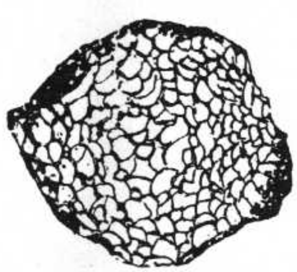
X3

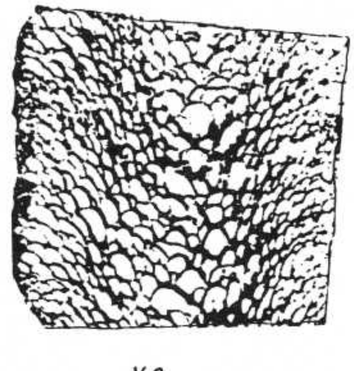


X4

Eridophyllum seriale





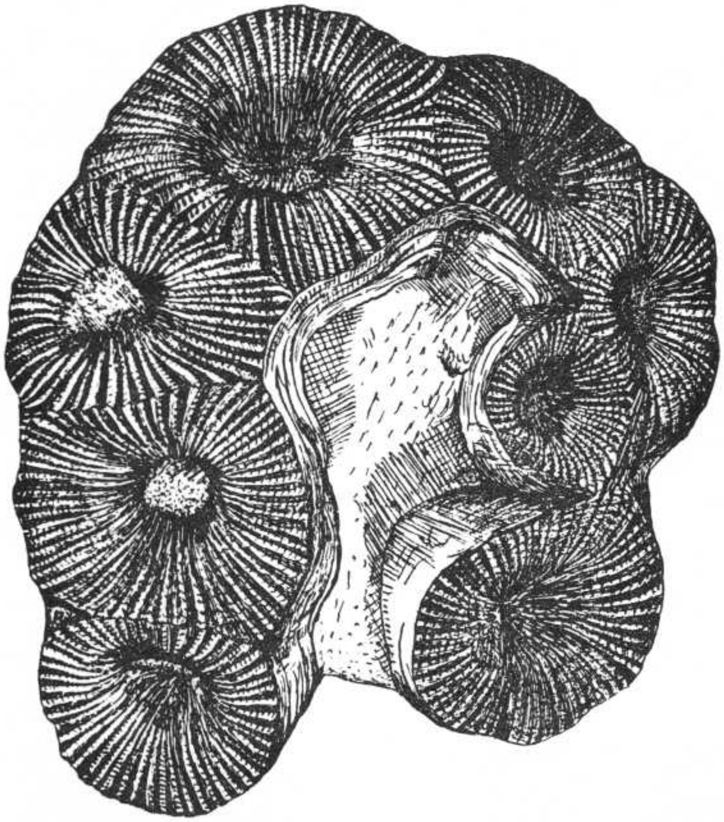


Cystiphylloides americanum

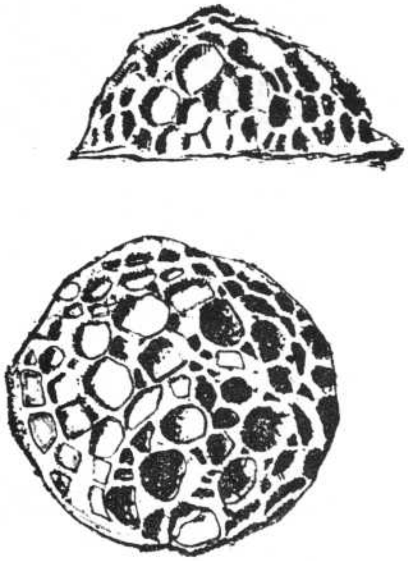
X2

NOTE: All figures natural size unless otherwise noted.

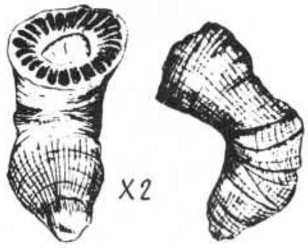
Figure B-4



Heliophyllum confluens



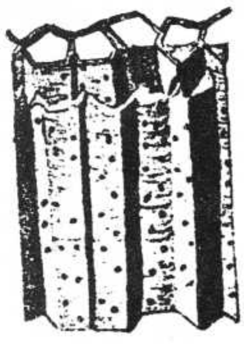
Pleurodictyum americanum



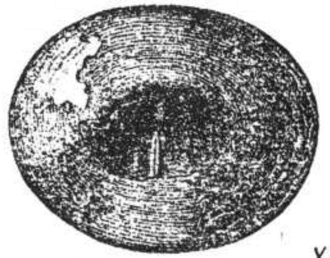
X2

Amplexiphyllum hamiltoniae

X2



Favosites hamiltoniae



X2

Roemerella grandis

Lingula spatulata

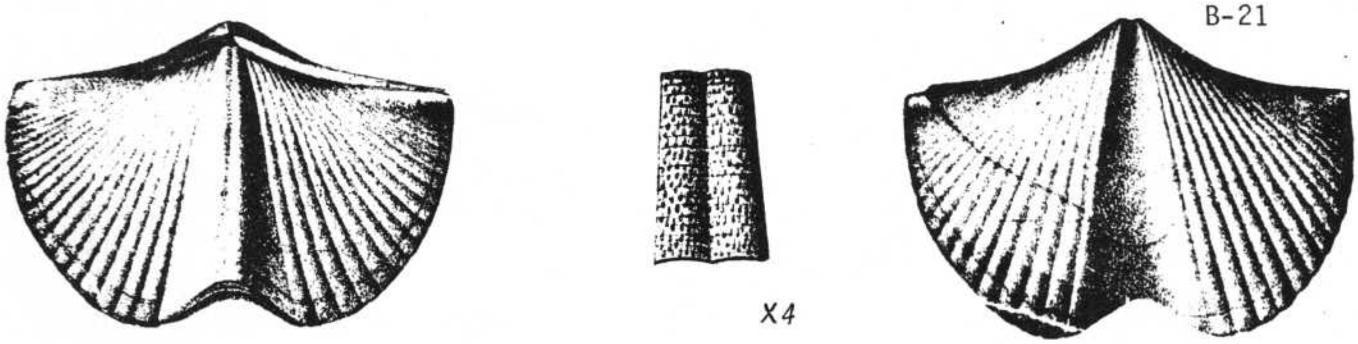
"Leiorhynchus" multicostum

Orbiculoidea media

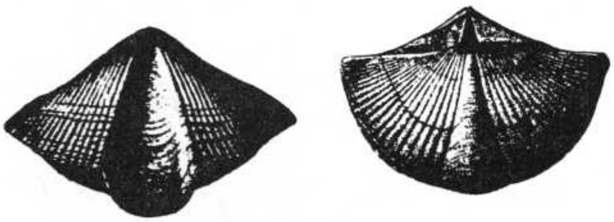
Figure B-5


X3
"Camarotechia" sappho
X2
Ambocoelia umbonata
X2
"Camarotechia" congregata
Pentamerella pavilonensis
Chonetes coronatus
X2
Chonetes scitula
Productella spinulicosta
Strophalosia truncata
Cryptonella planirosta
Vitulina pustulosa
Elytha fimbriata
X2
Cyrtina hamiltonensis
Spirifer sculptilis
Parazyga hirsuta

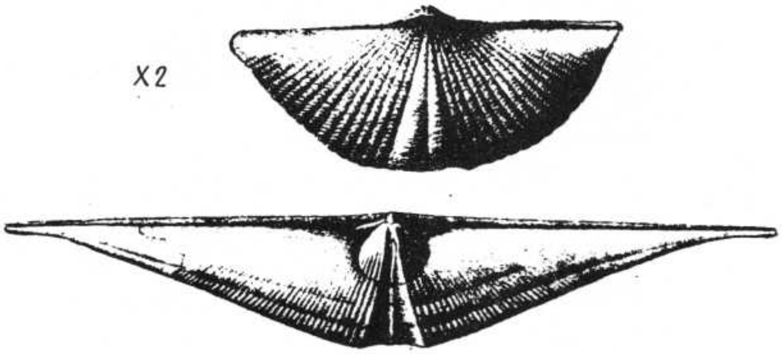
Figure B-6



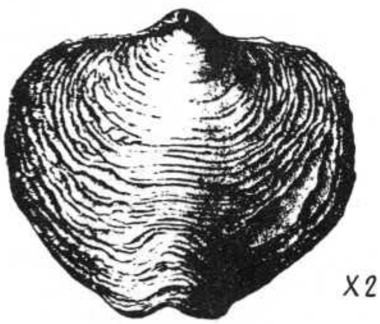
Spinocyrtia granulosa



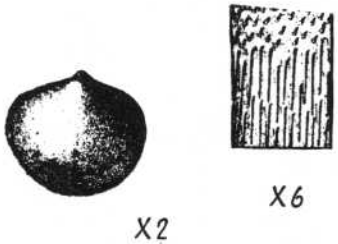
Mediospirifer audaculus



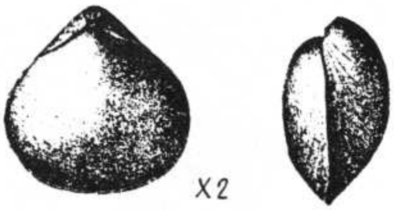
Mucrospirifer mucronatus



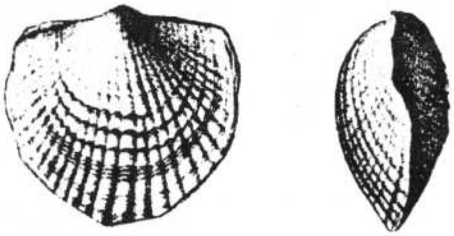
Athyris spiriferoides



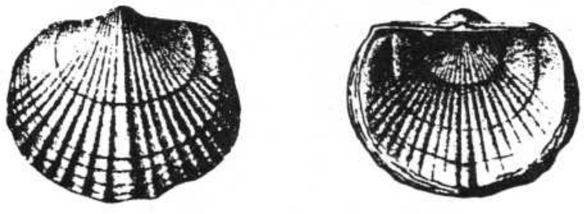
Nucleospira concinna



Meristella haskinsi

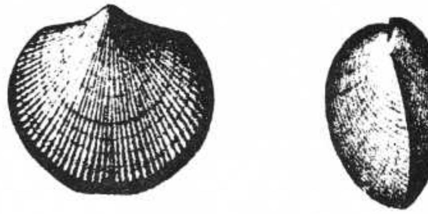


Spinatrypa spinosa

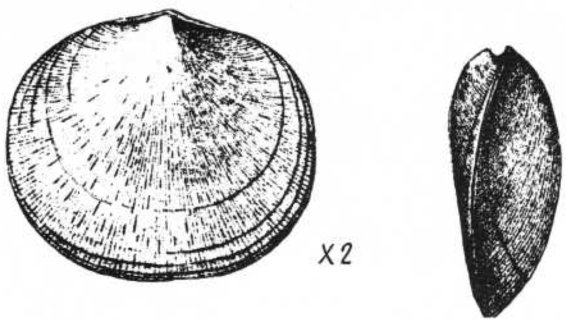


Tropidoleptus carinatus

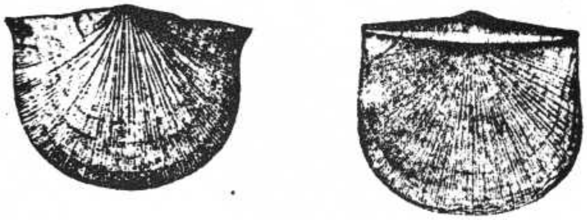
Figure B-7



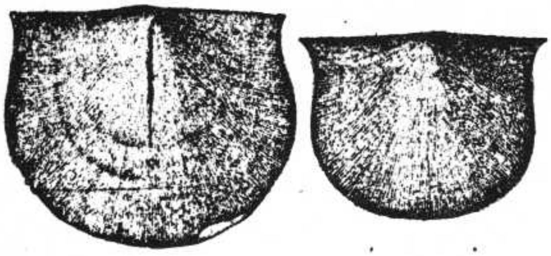
Atrypa reticularis



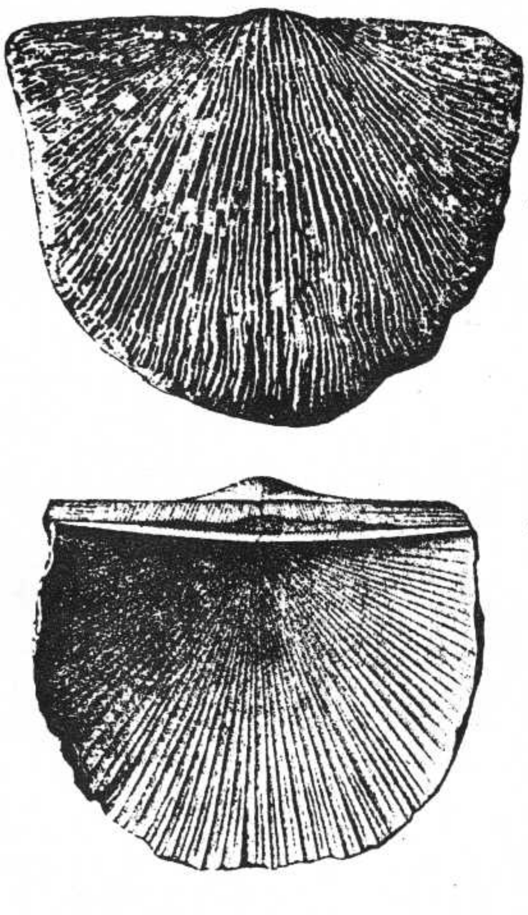
Rhipidomella penelope

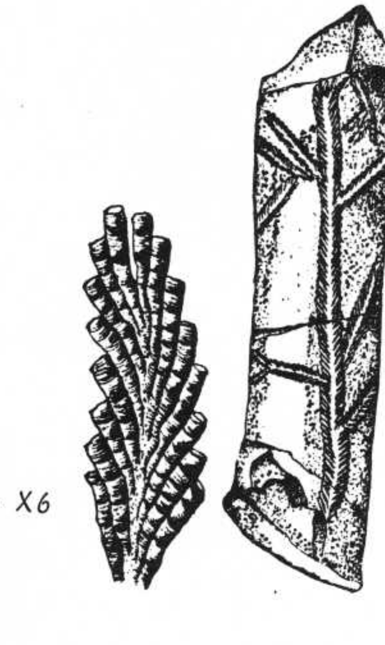


Stropheodonta demissa



Protoleptostrophia perplana

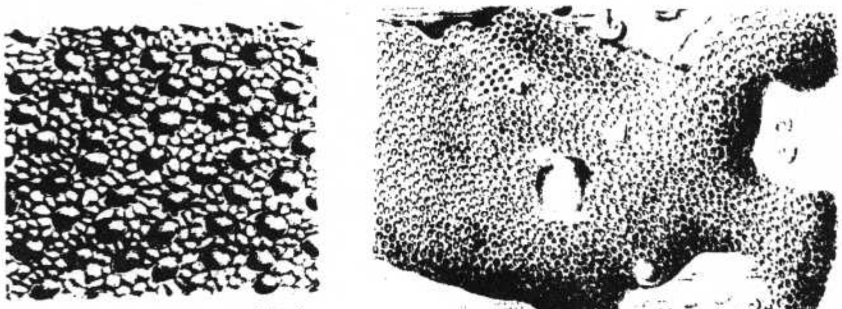




Reptaria stolonifera

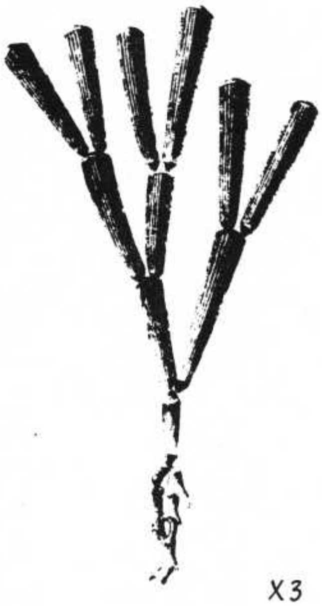
Megastrophia concava

Figure B-8



X18 X6

Fistulipora multaculeata



X3

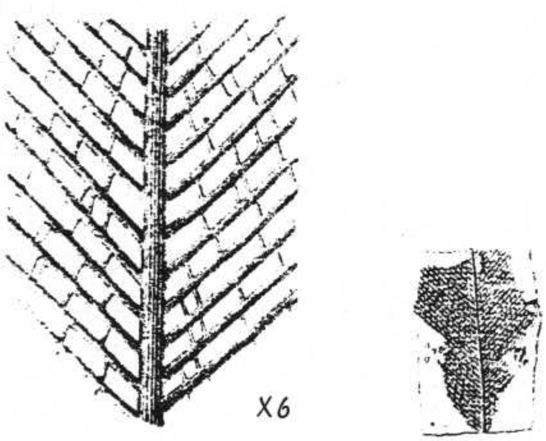
Acrogenia prolifera

X12

X8

Hederella filiformis

Hederella canadensis



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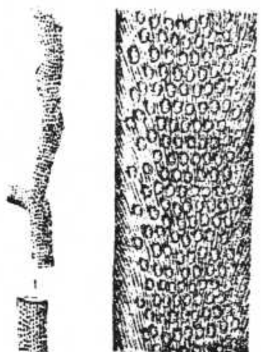
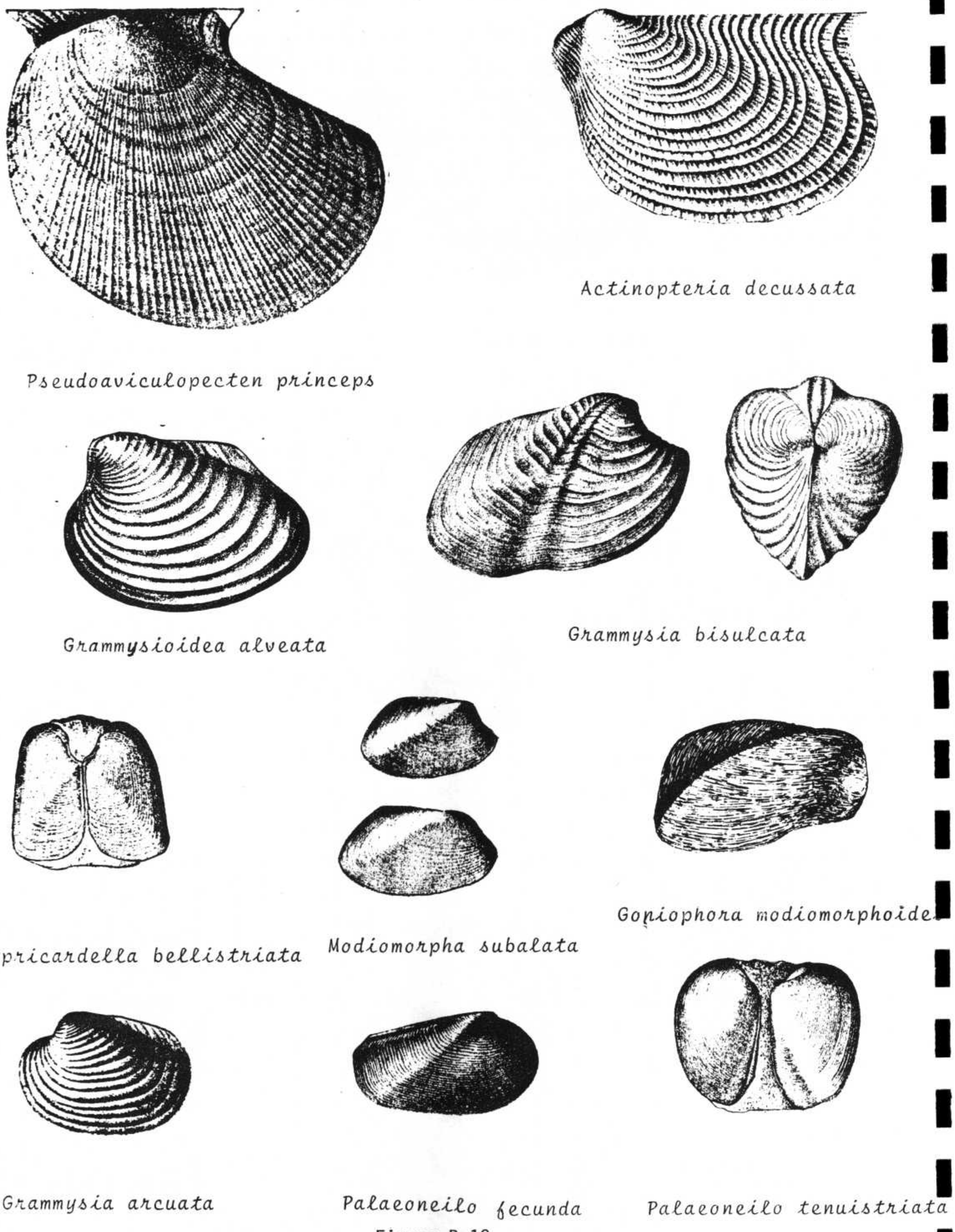


X6

Stictopora interstriata

Ptilopora striata

Figure B-9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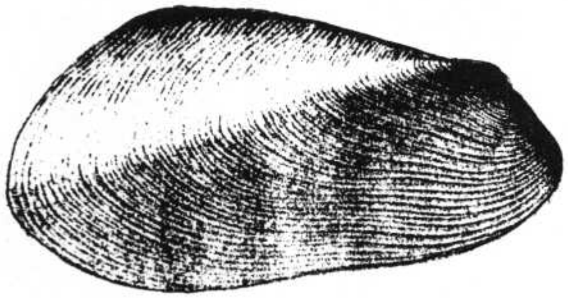
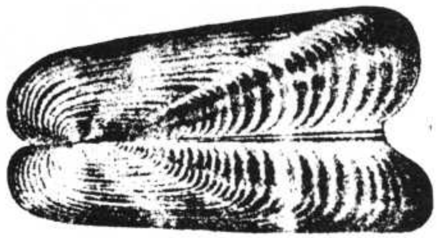
Goniophora modiomorphoides
Cypricardella bellistriata
Modiomorpha subalata
Grammysia arcuata
Palaeoneilo fecunda
Palaeoneilo tenuistriata

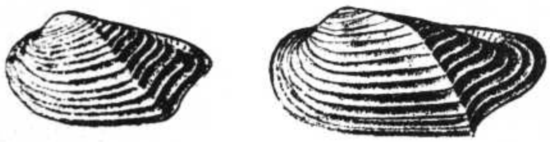
Figure B-10



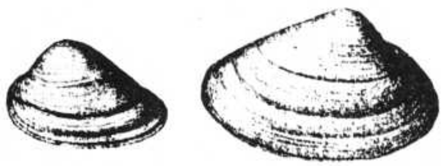
Modiomorphia concentrica



Orthonata undulata



Palaeoneilo emarginata



Nucula corbuliformis

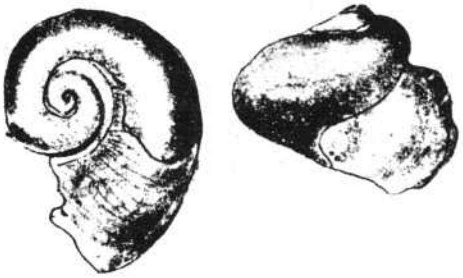
Nuculites oblongatus

Nuculites nyssa

Nuculites triqueter

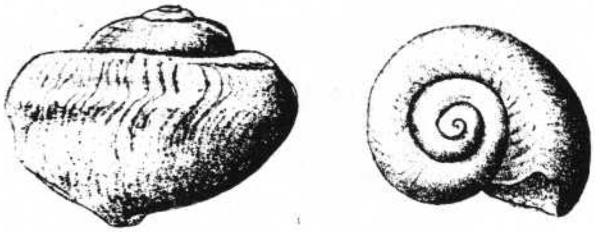
Platyceras thetis

Platyceras symmetricum

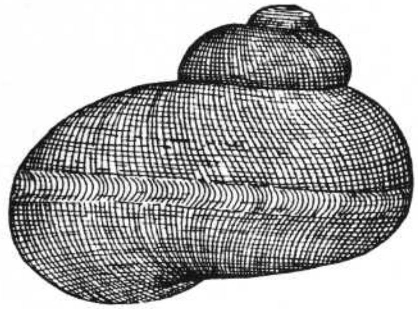


Platyostoma sp.

Figure B-11



Platyostoma turbinatum



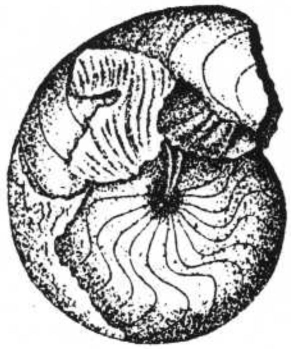
Mourlonia lucina

Paleczygopleura (Loxonema) hamiltoniae

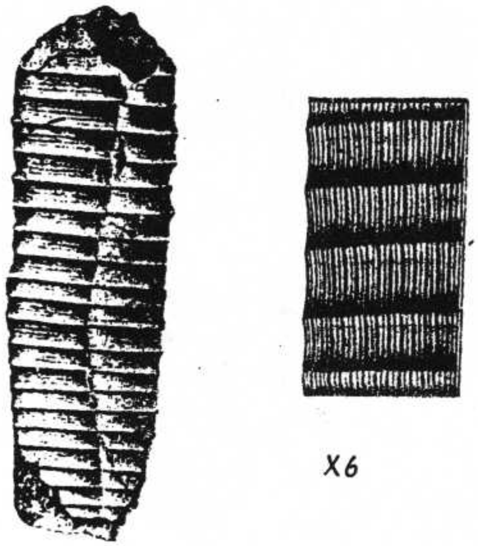
Naticonema lineata

X10

Styolina fissurella

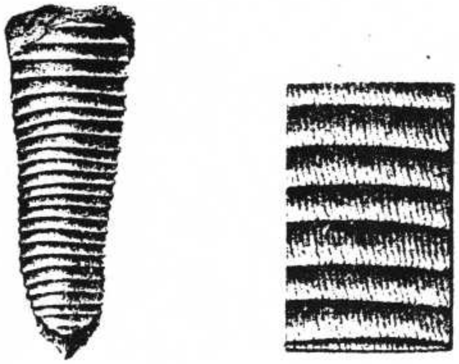


Tornoceras uniangularis



X6

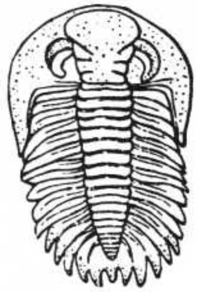
Spyroceras nuntium



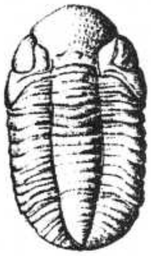
X6

Spyroceras idmon

Figure B-12

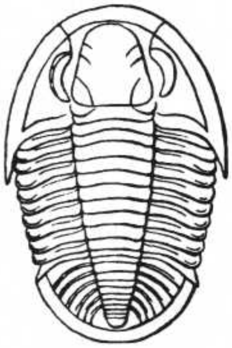


Greenops boothi

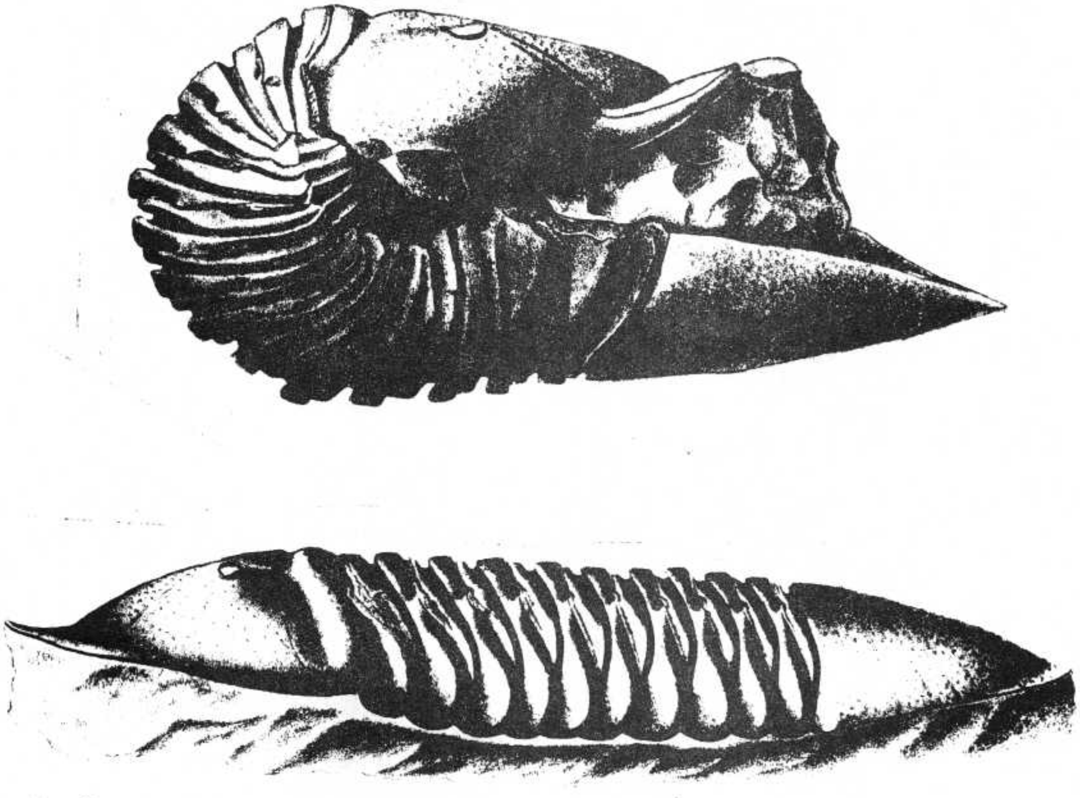


Phacops rana

Taonurus cauda-galli



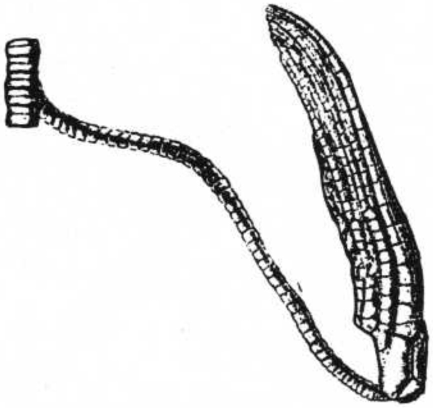
Proetus rowi



Trimerus (Dipleura) dekayi

Echinocaris punctata

Figure B-13



Deltacrinus clarus

Acanthocrinus spinosus

Devonoblastus leda

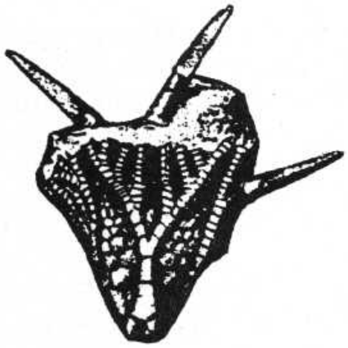
Pentremitidea goldringae

X2

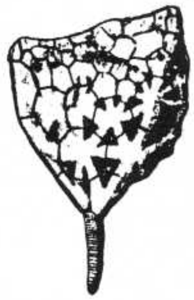
Ancyrocrinus spinosus

Dolatocrinus bellulus

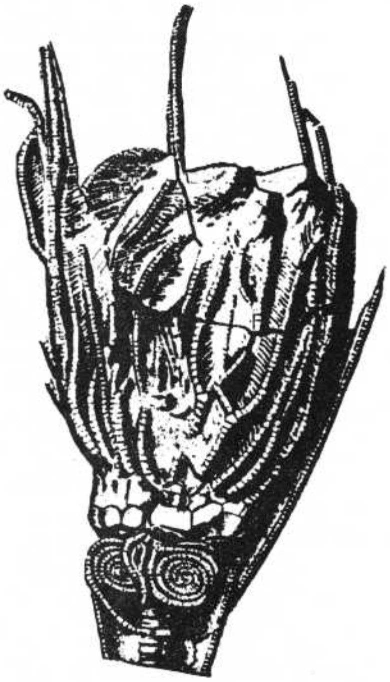
Figure B-14



Thamnocrinus springeri



Corocrinus ornatus

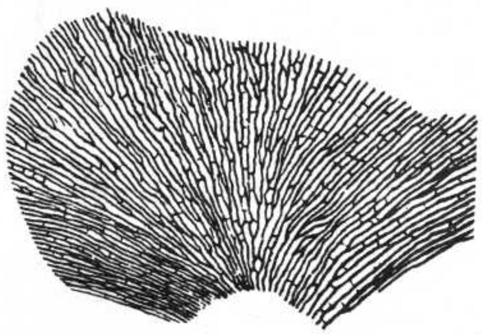


Clarkeocrinus troosti

Gennaecrinus carinatus

Aorocrinus armatus

Arthroacantha punctobranchiata



Dictyonema hamiltoniae

Figure B-15

REFERENCES

Baird, G.C. 1978. Pebbly phosphorites in shale: a key to recognition of a widespread submarine disontinuity in the Middle Devonian of New York: Jour. Sed. Pet. v.2., no.2 p. 545-555.

__________ 1979. Sedimentary relationships of Portland Point and associated Middle Devonian rocks in central and western New York: N.Y. St. Mus. Bull. no.433, 24pp.

Bowen, Z.P. Rhoads, D.C., and McAlester, A.L. 1974. Marine benthic communities of the Upper Devonian of New York: Lethaia v.7, no.2, p. 93-120.

Bray, R.G. 1971. Ecology and life history of Mid-Devonian brachiopod clusters: Unpub. Ph. D. dissert., McMaster Univ., 162pp.

Bretsky, P. 1970. Late Ordovician benthic marine communities in north-central New York: N.Y. St. Mus. Bull. no.414, 34pp.

Brower, J.C., et. al. 1978. Faunal assemblages in the lower Hamilton Group in Onondaga County, New York, In N.Y. St. Geol. Assn. Guidebook 50th Ann. Mtg., Syracuse Univ.: p. 104-123.

Clarke, J.M. 1903. Classification of New York Series of geologic formation: N.Y. St. Mus. Hdbk. no.19, 1st ed., 28pp.

__________ and Luther, D.D. 1904. Stratigraphic and paleontologic map of Canandaigua and Naples quadrangles: N.Y. St. Mus. Bull. no.53, p. 1-67.

Cooper, G.A. 1930. Stratigraphy of the Hamilton of New York: Amer. Jour. Sci., 5th ser., v.19, no.111 p. 116-134. no.111 p. 214-236.

__________ 1933. Stratigraphy of the Hamilton Group of eastern New York: Am. Jour. Sci., 5th ser., v.26, no.156. p. 537-551.

Driscoll, E.G. 1969. Animal-sediment relationships of the Coldwater and Marshall Formations of Michigan, In Cambell, k.s.w. ed., Stratigraphy and paleontology - essays in honor of Dorothy Hill: p. 337-352.

Grabau, A.W. 1917. Age and Stratigraphic relations of the Olentangy Shale of central Ohio: Jour. Geo. v.25, p. 337-343.

__________ 1917. Stratigraphic relationships of the Tully and the Genesee Shale in eastern North America: Geo. Soc. Amer. Bull. v.28, p. 945-958.

Grasso, T.X. 1973. A comparison of environments - the Middle Devonian Hamilton Group in the Genesee Valley, In N.Y. St. Geol. Assn. Guidebook 45th Ann. Mtg., SUNY at Brockport and Monroe Community College: p. B1-B27.

__________ 1978. Benthic communities of the Ludlowville and Moscow Formations (Upper Hamilton Group) in the Tully Valley, Onondaga Co., In N.Y. St. Geol. Assn. Guidebook 50th Ann. Mtg., Syracuse Univ.: p. 143-172.

__________ and Wolff, M.P. 1977. Paleoenvironments of the Marcellus and Lower Skaneateles Formations of the Otsego Co. region, In N.Y. St. Geol. Assn. Guidebook 49th Ann. Mtg., SUNY at Oneonta: A3 50pp.

Hall, J. 1839. Third annual report of the Fourth geological district of the State of New York, p. 287-329.

Johnson, R.G. 1964. Community approach to paleoecology, in Imbrie, J. and Newell, N.D. eds., Approaches to Paleoecology: John Wiley and Sons, Inc., New York, p. 107-134.

Kramers, W.J. 1970. The Centerfield Limestone (Middle Devonian) of New York State and its clastic correlatives: a sedimentological analysis: Unpub. Ph. D. dissert. Rensselaer Polytech. Inst., 126pp.

McGhee, G.R. Jr. 1976. Late Devonian benthic marine communities of the central Appalachian Alleghany Front: Lethaia, v.9, p. 111-136.

Molander, A.R. 1930. Animal communities on soft bottom areas in the Gullmar Fjord: Uppsala Kristinebergs Zoologiska Station, 1877-1927, v.2, p. 1-90.

Okita, P.M. 1980. Stratigraphy and paleoecology of the Windom Shale (Moscow Formation, Hamilton Group) in the Middle Devonian of western New York: Unpub. Sen. Thesis, Univ. Rochester, 64pp.

Oliver. W.A. 1951. Middle Devonian coral beds of central New York: Am. Jour. Sci., v.249, p. 705-728.

Petersen, C.G. 1913. Animal communities of the sea bottom and their importance for marine zoogeography: Rep. Danish Biol. Sta., v.21, 68pp.

Scott, R.W. 1976. Trophic classification of benthic communities, In Scott, R.W. and West R.R. eds., Structure and Classification of Paleocommunities: Dowden, Hutchison, and Ross Inc., Stroudsbury, Pa., p. 25-66.

Stanley, S.M. 1972. Functional morphology and evolution of byssally attached bivalve mollusks: Jour. Paleo., v.46, no.2, p. 165-212.

Stanton, R.G., Jr., and Dodd, J.R. 1976. Application of trophic structure of fossil communities in paleoenvironmental reconstruction: Lethaia, v.9, p. 327-342.

Sutton, R.G., Bowen, Z.P., and McAlester, A.L. 1970. Marine shelf environments of the Upper Devonian Sonyea Group of New York: Geol. Soc. Amer. Bull., v.81, p. 2975 2992.

Titus, R. and Cameron, B. 1976. Fossil communities of the Lower Trenton Group (Middle Ordovician) of central and northwestern New York State: Jour. Paleo., v.50 no.6, p. 1209-1225.

Zeigler, A.M. 1965. Silurian marine communites and their paleoenvironmental significance: Nature, v.207, p. 270-272.

__________, Cocks, L.R. M., and Banbach, R. 1968. Composition and structure of Lower Silurian marine communities: Lethaia, v.1, p. 1-27.

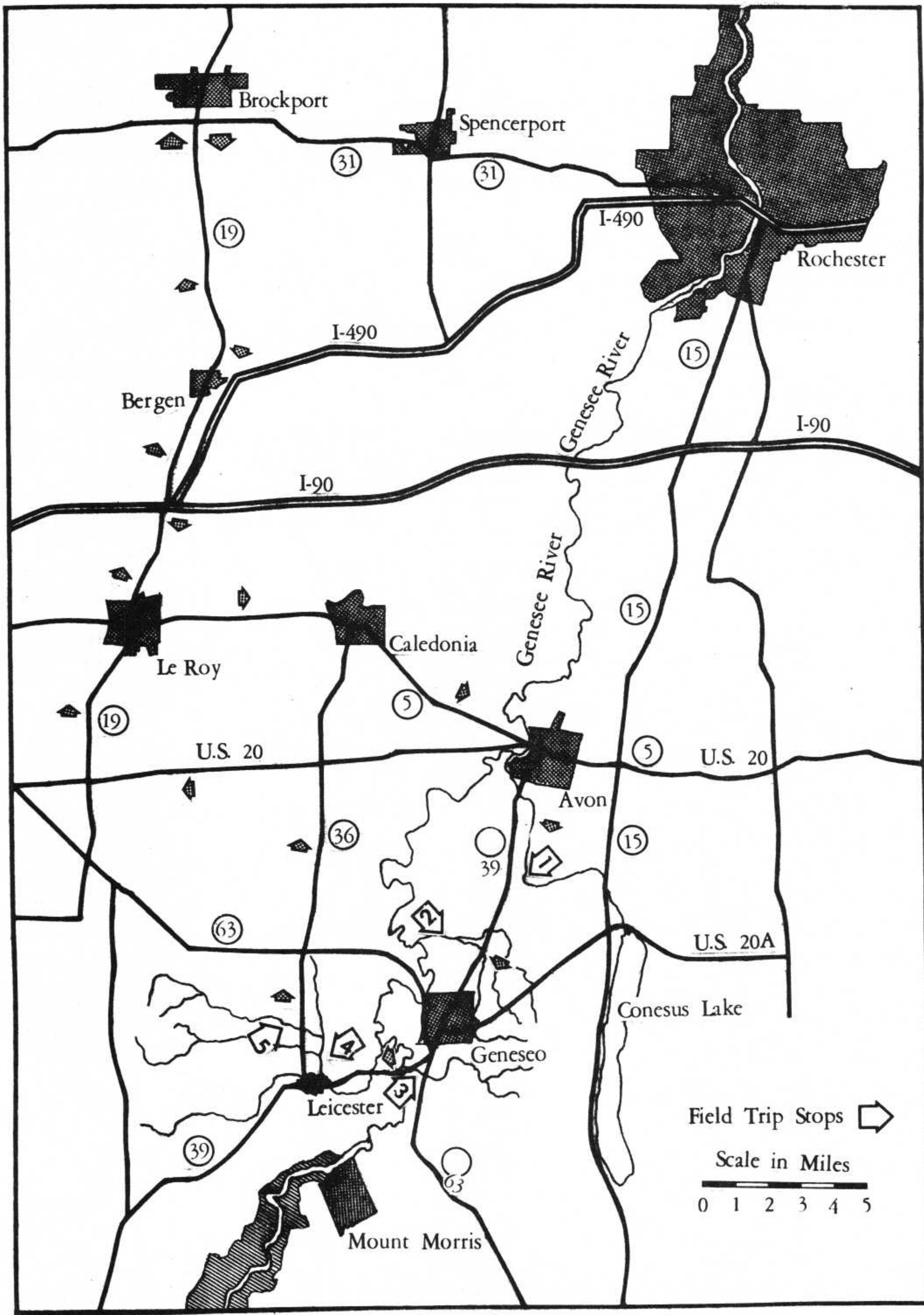

Brockport
Spencerport
Rochester
31
31
19
I-490
I-490
Bergen
Genesee River
15
I-90
I-90
Genesee River
15
Le Roy
Caledonia
5
19
U.S. 20
Avon
5
U.S. 20
36
39
1
15
2
63
U.S. 20A
Conesus Lake
5
4
Geneseo
3
Leicester
Field Trip Stops
Scale in Miles
0 1 2 3 4 5
39
63
Mount Morris

Figure B-16

ROAD LOG

Hamilton Group

NOTE: Road log begins in Avon, New York at the Jct. of US 20-NY 5 and NY 39.

Miles From Last Point	Cumulative Miles	Route Description
0.0	0.0	Junction N.Y. 39 and U.S. 20-N.Y. 5 on right. Turn right (south) on N.Y. Rt.39.
1.2	1.2	Ashantee
1.9	3.1	Papermill Road on left. Proceed south on N.Y. 39.
1.1	4.2	Triphammer Road on left. Turn left (east) onto Triphammer Road.
0.3	4.5	Gate on left just west of Conesus Creek.
		STOP #1-TRIPHAMMER FALLS The uppermost Levanna Shale Member of the Skaneateles Formation is exposed downstream from the falls. The caprock of the falls is the basal Ludlowville Centerfield Limestone Member.
0.5	5.0	Return to N.Y. 39 - turn left (south)
1.3	6.3	Cross North Branch - Jaycox Run
1.1	7.4	Nations Road on right - turn right (west) Proceed on Nations Road to old railroad embankment.
		STOP #2-JAYCOX RUN Nearly a complete section of the Ludlowville and lower Moscow Formations is exposed here beginning with the Centerfield Limestone Member and ending with the Menteth Limestone Member.
1.1	9.6	Return to N.Y. 39 on Nations Road. Turn left (south) on N.Y. 39
1.2	10.8	Enter Geneseo
1.0	11.8	State University College at Geneseo on right.

0.2	12.0	Junction N.Y. 39 and U.S. 20A Turn right (west) on U.S. 20A-N.Y. 39
0.7	12.7	N.Y. 63 on right. Proceed striaght (south) on U.S. 20A-N.Y. 39.
0.2	12.9	Fork in road. Bear right on U.S. 20A-N.Y. 39.
0.3	13.2	Geneseo Black Shale in road cut.
0.4	13.6	STOP #3-FALL BROOK The section begins in the middle Windom Shale Member of the Moscow Formation. The Upper Devonian Leicester Pyrite is exposed on the sides of the gorge succeeded by the Geneseo Black Shale, Penn Yan Shale and the Genundewa Limestone (Genesee Group) capping the large falls upstream.
0.2	13.8	Cross Genesee River
1.0	14.8	Cross Beards Creek
0.0	14.8	Boyd Parker Monument of left. Site of the murder of Lieutenant Boyd and Captain Parker, two members of General Sullivan's campaign of 1779 against the Iroquois Confederacy to end their continual harassment of colonial frontier settlements in New York. The victims' execution was prefaced by the most insidious torture apparently at the direction of the infamous Mohawk Valley Tory, Colonel Walter Butler.
0.3	15.1	Enter village of Cuylerville. Cross line of the old Genesee Valley Canal which connected Olean with the Erie Canal at Rochester. The Genesee Valley Canal was completed in 1856 and abandoned in 1878. Proceed on U.S. 20A-N.Y. 39.
1.2	16.3	Enter village of Leicester.
0.2	16.5	Junction N.Y. 36 - proceed straight (west) on U.S. 20A-N.Y. 39-N.Y. 36.

0.1	16.6	Turn right (north) on N.Y. 36.
0.8	17.4	Trailer Park and Kingston Road on right. Turn right on Kingston Road and proceed to dead end.
0.4	17.8	End of Kingston Road.
		STOP #4-LITTLE BEARDS CREEK The Windom Member disconformity overlies a few feet of the Kashong Member, the contact marked by a pebbly phosphatic zone. The section is capped by the Geneseo Black Shale. The Kashong Shale is exposed in the lower 2-3 feet, overlain by 47 feet of Windom, at this locality and it carries an excellent "Moscow" facies fauna.
0.4	18.2	Return to N.Y. 36. Turn right (north) on N.Y. 36.
0.5	18.7	New road on left; "Empire Dragway" sign.
0.2	18.9	Cross Taunton Creek.
0.1	19.0	First white house on left - north of Taunton Creek.
		STOP #5-TAUNTON GULLY The upper 25 or so feet of the Windom Member is exposed at the base of the exposure. Upstream from this point there is nearly a continuous section from the Leicester Pyrite to the Genundewa Limestone which caps a waterfall at an elevation of about 850 feet.
		END OF TRIP - Return to Brockport via N.Y. 36; U.S. 20; and N.Y. 19.

TRIP C

GLACIAL GEOLOGY OF THE GENESEE VALLEY—DANSVILLE-NAPLES REGION

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State University College at Geneseo
Geneseo, New York 14454

This trip presents an overview of selected glacial erosional and depositional landforms of lacustrine, fluvial, and ice-contact origin. The emphasis is on high-level proglacial lake features in the Genesee Valley and the strong topographic influences on ice flow and deposition from Dansville to Honeoye. The maps and features described are intended to be useful for high school earth science classes or introductory college geology courses.

GLACIAL GEOLOGY OF THE GENESEE VALLEY—DANSVILLE-NAPLES REGION

The objective of this trip is to provide an integrated view of the interesting glacial features that formed approximately 15,000 to 12,000 years ago as the Wisconsinan ice sheet "retreated" from the Valley Heads moraine near Dansville to the vicinity of Brockport and Rochester, a distance of approximately 50 miles. The northernmost edge of the Valley Heads moraine complex near Dansville represents an ice readvance that produced tills incorporating older outwash deposits, deltaic sands, and varved lake clays from the Canaseraga Valley.

During the 3000-year interval when the ice retreated northward, at least one other significant readvance near Geneseo may have occurred about 13,000 years ago. Several stationary positions are demonstrated by the moraines in the Genesee Valley drawn on the map, Quaternary Geology of New York, Niagara Sheet (Muller, 1977; this report, Figure 1b). The 1000-foot elevation lake stage in the Genesee Valley (Fig. 1b) was the largest local lake related to the onset of westward ice-marginal drainage (Pearl Creek outlet, Figure 8). Fairchild (1907) first referred to it as the "Warren tributary lake" and later designated it as Lake Newberry (transitional with Lake Hall). Numerous lake outlets are visible between 1000 and 900 feet in the Genesee Valley (Fairchild, 1928). The reader is referred to Calkin (1970) and Calkin and McAndrews (1980) for discussions of the events that occurred as the ice retreated northward from this position.

Lake Newberry left the most obvious geologic evidence of its presence in the Genesee Valley when compared to all of the older or younger lake stages, except for Lake Warren. However, Lake Warren was much larger with only a

relatively small embayment occupying the Genesee Valley at elevations between 840 feet and 880 feet.

The 1000-foot lake stage may have reoccurred during a postulated readvance that ended(?) north of Geneseo, if that event coincided closely with formation of the large moraine on Figure 9 (see also Figure 27). This moraine system consists of at least 70 feet of till overlying varved clays at the site of the Oxbow Lane landslide (Figure 9). Also, deformed varved sediments occur on the west side of the Genesee Valley at nearly the same latitude. Thick varved clays that are present south of this moraine system indicate no apparent evidence of glacier readvance. However, numerous cobbles and till masses were dropped into the lake sediments as the varves were being deposited. The varve thicknesses (6 to 8 inches or more) and rafted debris suggest proximity to the ice margin.

Prior to the 1000-foot lake stage, the glacial meltwater had drained southward at Dansville (Figure 16) and North Cohocton (Figure la). As the ice retreated from the Valley Heads moraine, a series of gradually lowering lake levels were created ending with Lake Iroquois about 12,600 years ago (Calkin and McAndrews, 1980). A number of the lakes immediately below the 1000-foot stage drained westward as indicated by the numerous ice-marginal channels on Figures 7, 31, and 32. A post-Iroquois low stage 140 feet below modern Lake Ontario has recently been documented at Rochester (Young, 1980). All of the local elevations cited above must be viewed regionally within the context of differential postglacial rebound.

The precise chronology of this phase of New York glacial history has not been completely established, but it falls generally within the time limits of 15,000 to 12,000 B.P., based on a few radiocarbon dates in western New York and reasonable assumptions based on modern studies of large ice sheets.

A shallow "Finger Lake" blocked by the morainal plug shown on Figures 26 and 27 persisted for an unknown period in the Genesee-Canaseraga Valley between Geneseo and Dansville. Lake sediments overlain by peat deposits about 11,000 years old lie 30 to 35 feet beneath the modern floodplain (Mansue, et al., in press).

FIELD TRIP ROUTE

The field trip will illustrate the following interesting relationships: (1) superposition of the 1000-foot shoreline features on older deposits, such as the Valley Heads moraine, (2) evidence of postglacial capture of the Upper Canaseraga Creek near Poag's Hole, (3) an unusual "interlobate" moraine and meltwater outlet west of Wayland (Figure 19), (4) small, lobate valley moraine remnants near Naples, and (5) numerous examples of well-developed lacustrine or ice-marginal glacial features. The features are labeled and marked on standard 7.5 minute USGS topographic map segments, which serve to define the trip route in place of the more standard road log. More features have been placed on the maps than it will be possible to stop and examine. This is intended to allow more flexibility for use of the guidebook or maps by future users.

The trip provides views of a wide range of glacial features produced within a relatively short geologic time span in a variety of topographic settings. The route was selected so that the major features could be observed regardless of weather conditions. Individual features can be viewed in a strictly geomorphological context, but an attempt has been made to integrate a number of features closely related in time to one of the major lake stages in the Genesee Valley. The glacial landforms near Naples differ from the rest

in that they more specifically emphasize the way in which topographic relief can produce a strongly lobate ice margin with complex ice-lobe interaction and distinctive ice-marginal landforms.

Topographic maps, published and unpublished geologic maps, and some aerial photographs will be used to help illustrate the field relationships. All of the area west of Avon is covered on the Niagara Sheet of the Quaternary Map of New York (Muller, 1977).

The entire field trip route can be followed with minor exceptions by viewing the individual topographic map sections shown on Figure 1b.

Selected Bibliography

Calkin, P.E., 1970, Strand lines and chronology of the glacial great lakes in northwestern New York: The Ohio Jour. Sci., v. 70, p. 78-96.

Calkin, P.E. and McAndrews, J.H., 1980, Geology and paleontology of two late Wisconsin sites in western New York: Geol. Soc. America Bull., v. 91, p. 295-306.

Fairchild, H.L., 1895, Glacial lakes of western New York: Geol. Soc. America Bull., v. 6, p. 353-374.

______________, 1907, Glacial waters in the Lake Erie Basin: New York State Museum Bull., v. 106, 83 p.

______________, 1909, Glacial waters in central New York: New York State Museum Bull., v. 127, 66 p.

______________, 1926, The Dansville Valley and drainage history of western New York: Rochester Acad. Sci. Proc., v. 6, p. 217-242.

______________, 1928, Geologic story of the Genesee Valley and western New York: Pub. by author, Rochester, N.Y., 215 p.

Mansue, L.J., Young, R.A., and Soren, J., IN PRESS, Hydrologic Influence on sediment-transport patterns in the Genesee River Basin, N.Y.: U.S. Geological Survey Project Report for International Joint Commission (PLUARG) Studies of Great Lakes Pollution to Environmental Protection Agency.

Mansue, L.J., Young, R.A., and Miller, T.S., IN PRESS, Geology, water and sediment in the Canaseraga Valley Basin near Dansville, N.Y.: U.S. Geological Survey Project Report.

Muller, E.H., 1977, Quaternary geology of New York, Niagara Sheet: New York State Museum and Science Service Map and Chart Series 28.

Schmidt, V.E., 1973, Glacial geology of the western finger lakes region, P. A-1—A-21 in Hewitt, P.C. (ed.), N.Y. State Geol. Assoc. Guidebook for Field Trips at the 45th annual meeting.

Young, R.A., 1980, Post-Iroquois Low Level of Lake Ontario near Rochester, New York (abstr.): Program and Abstracts for 23rd Conference on Great Lakes Research, Intl. Assoc. for Great Lakes Research, p. 26.

Young, R.A., Scatterday, J.W., and Hill, J., 1980, Significance of the remains of a Pleistocene Peccary (Platygonus Compressus LeConte) beneath glacial till in Livingston Co., N.Y. (abstr.): Rochester Acad. Sci. Proc., v. 13, p. 151.

Suggested Stops

A	Figure 7	Gravel pit in moraine
B	Figure 9	Channel; till in road cut
C	Figure 10	Warren sandbar
D	Figure 11	Gravel pit in delta
E	Figure 11	Mt. Morris Dam; gorge
F	Figure 11	Incised meander
G	Figure 15	Stony Brook State Park
H	Figure 17	Moraine; outwash channel
I	Figure 19	Interlobate moraine
J	Figure 20	Boulder-veneered channel
K	Figure 21	Lateral moraine
L	Figure 24	Crevasse filling
M	Figure 25	Wave-cut drumlin
N	Figure 25	Warren shoreline
O	Figure 27	Landslide (till over varves)
P	Figure 26	River incised in till
Q	Figure 26	Lake delta; Conesus outlet
R	Figure 29	Warren shoreline
S	Figure 32	Peccary site (Young, 1980)
T	Figure 33	Warren gravel ridge

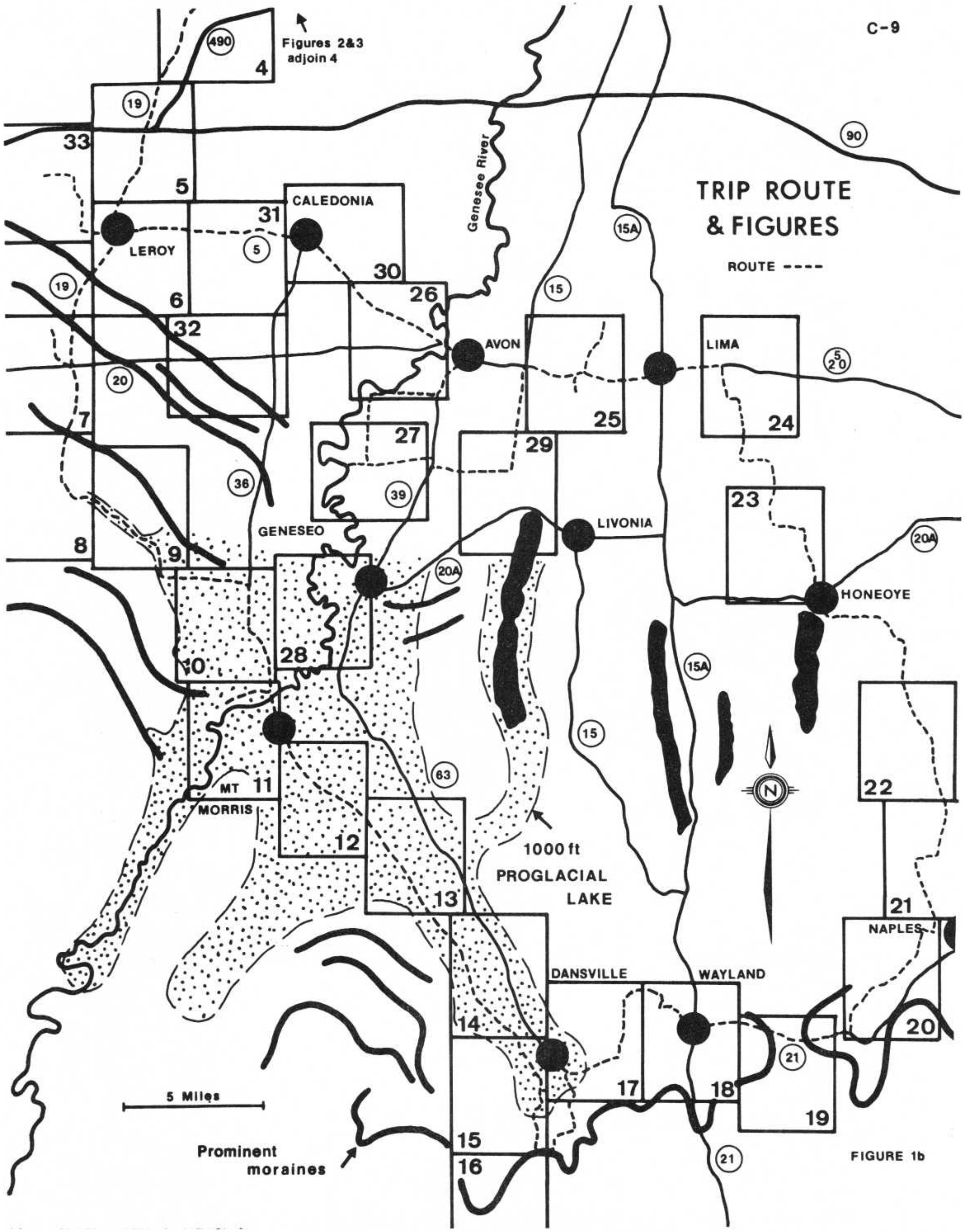
See also Figure 1a for stops B through S.
Moraines, eskers, shorelines, etc. approximately located with thin dashed lines.
Ice or outwash flow directions shown with arrows.
Trip route shown by thick dashed line.

FIGURE 1a

ELMIRA, NEW YORK; PENNSYLVANIA
1:250,000-scale Series

TRIP ROUTE
STOPS B through S

5 miles


TRIP ROUTE
& FIGURES
ROUTE ----
Figures 2&3
adjoin 4
LEROY
CALEDONIA
AVON
LIMA
LIVONIA
GENESEO
HONEOYE
MT
MORRIS
DANSVILLE
WAYLAND
NAPLES
Genesee River
1000 ft
PROGLACIAL
LAKE
5 Miles
Prominent
moraines
490
19
90
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15A
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36
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20A
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4
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FIGURE 1b

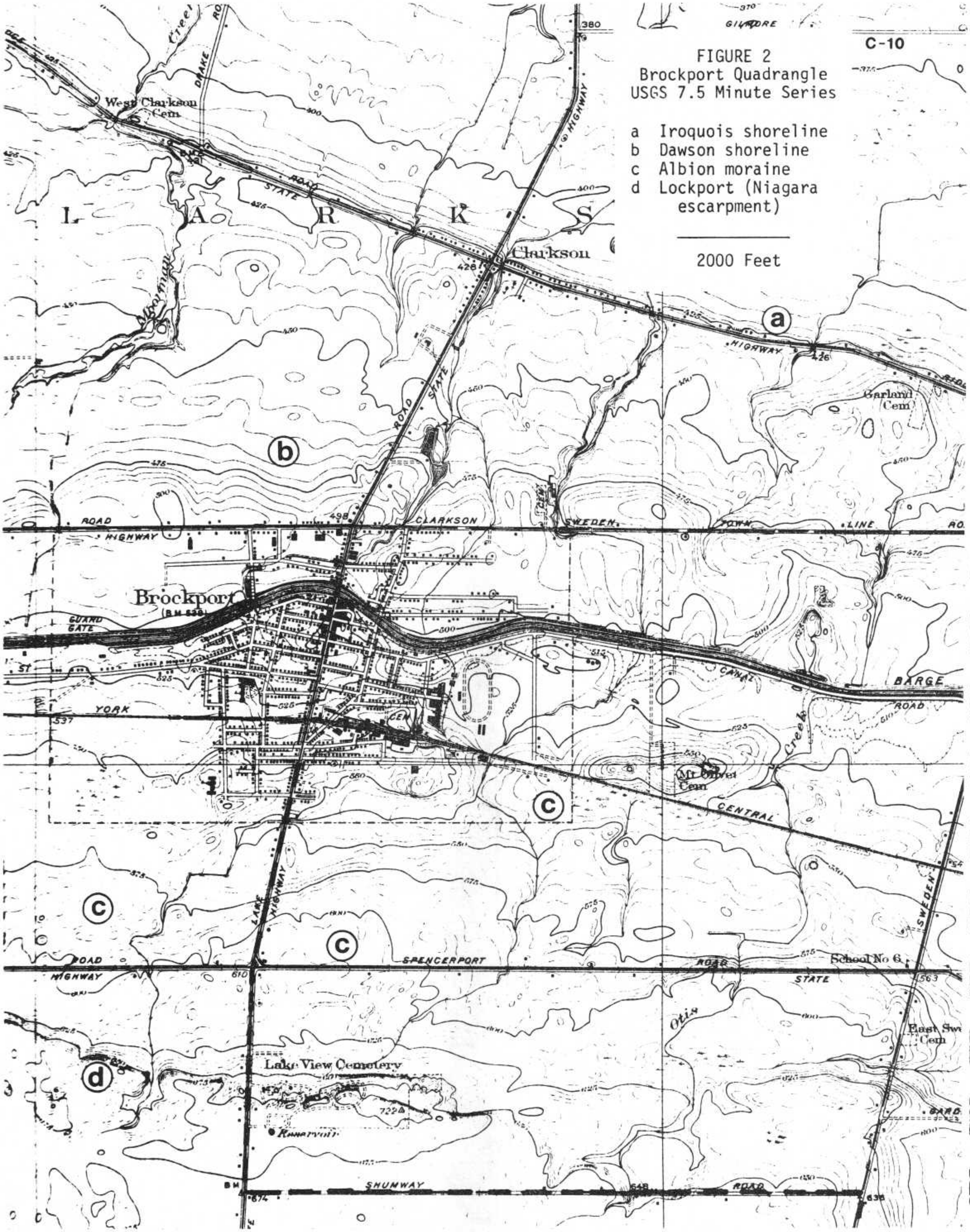

FIGURE 2
Brockport Quadrangle
USGS 7.5 Minute Series

a Iroquois shoreline
b Dawson shoreline
c Albion moraine
d Lockport (Niagara escarpment)

2000 Feet

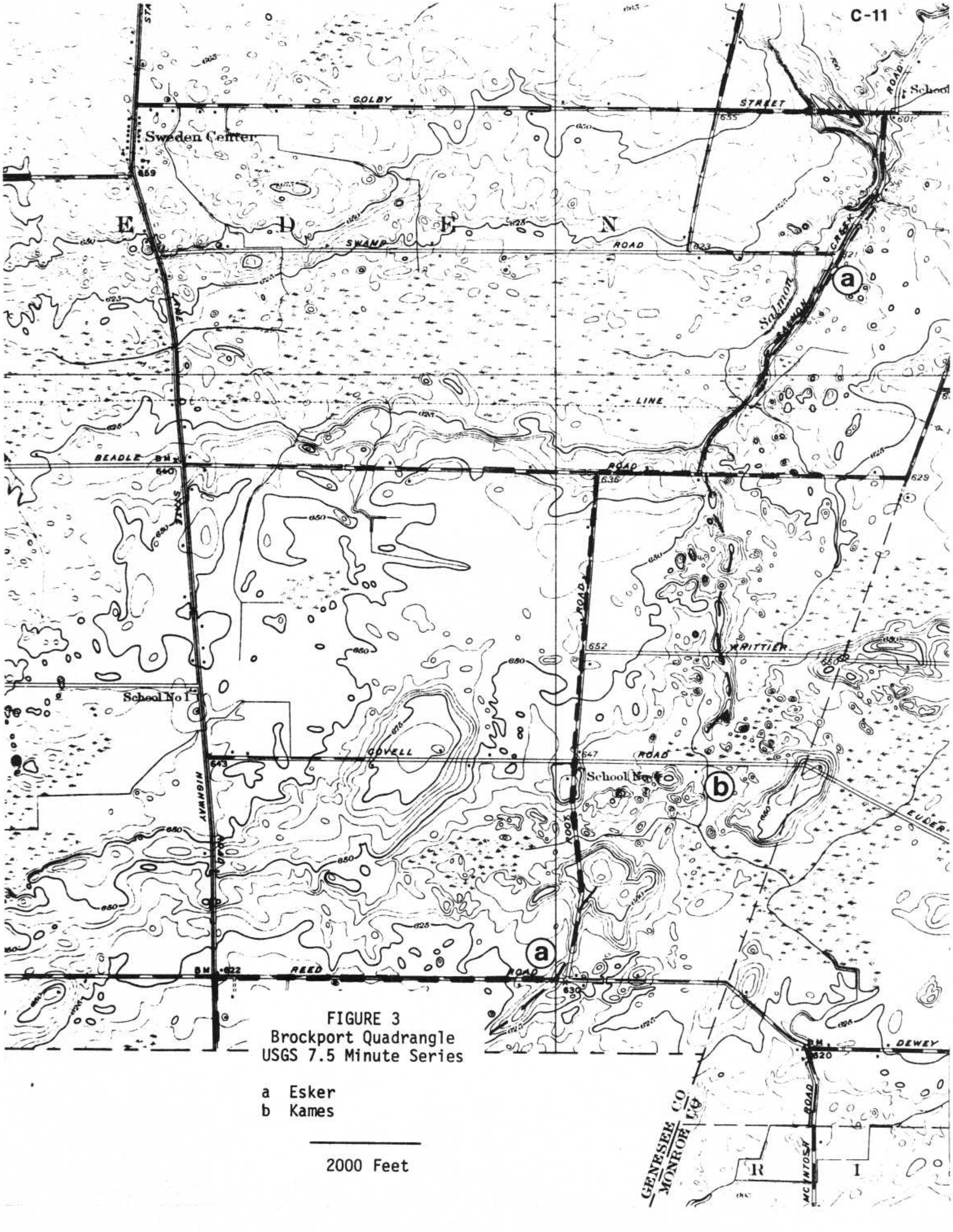

FIGURE 3
Brockport Quadrangle
USGS 7.5 Minute Series

a Esker
b Kames

2000 Feet

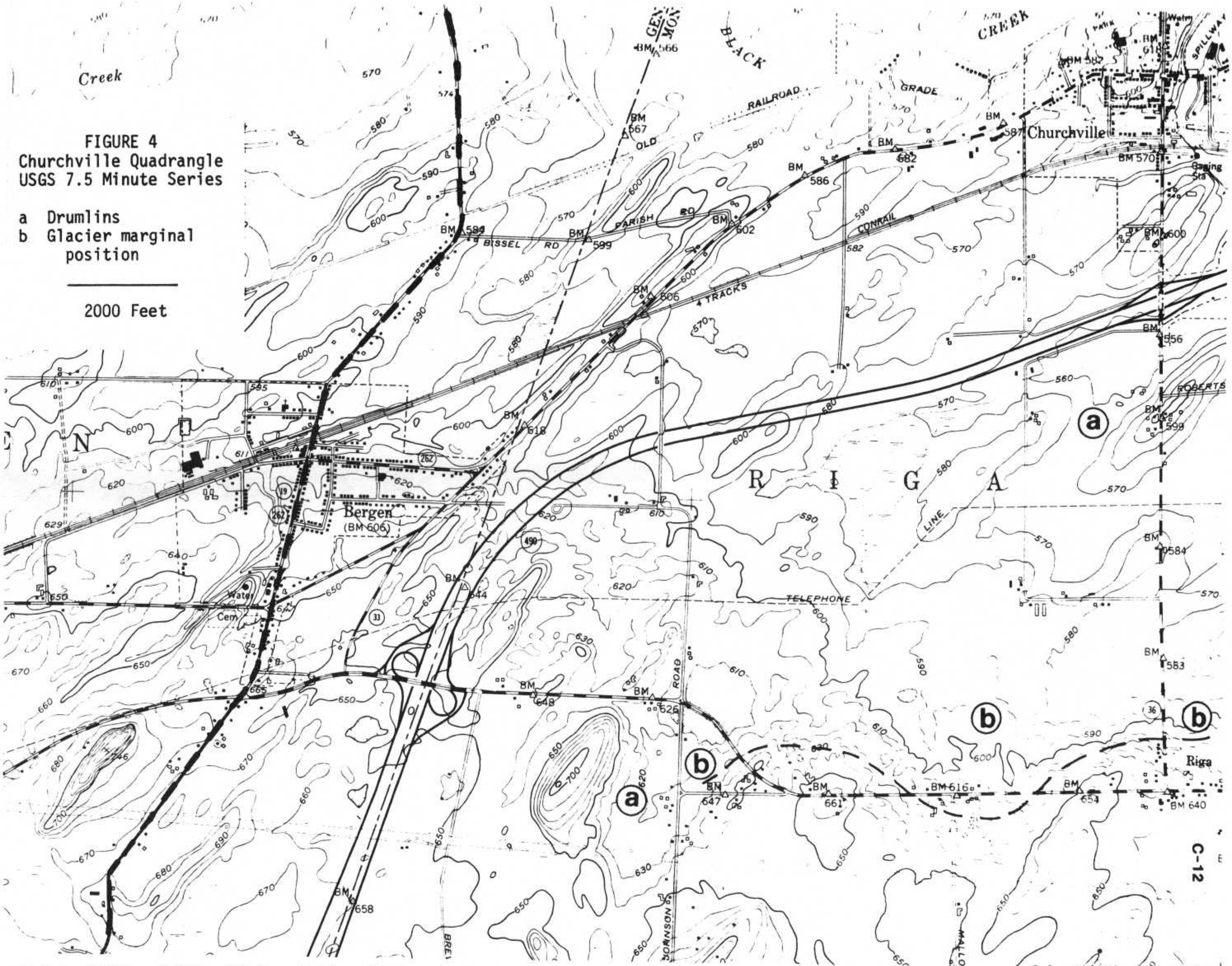

FIGURE 4
Churchville Quadrangle
USGS 7.5 Minute Series

a Drumlins
b Glacier marginal position

2000 Feet

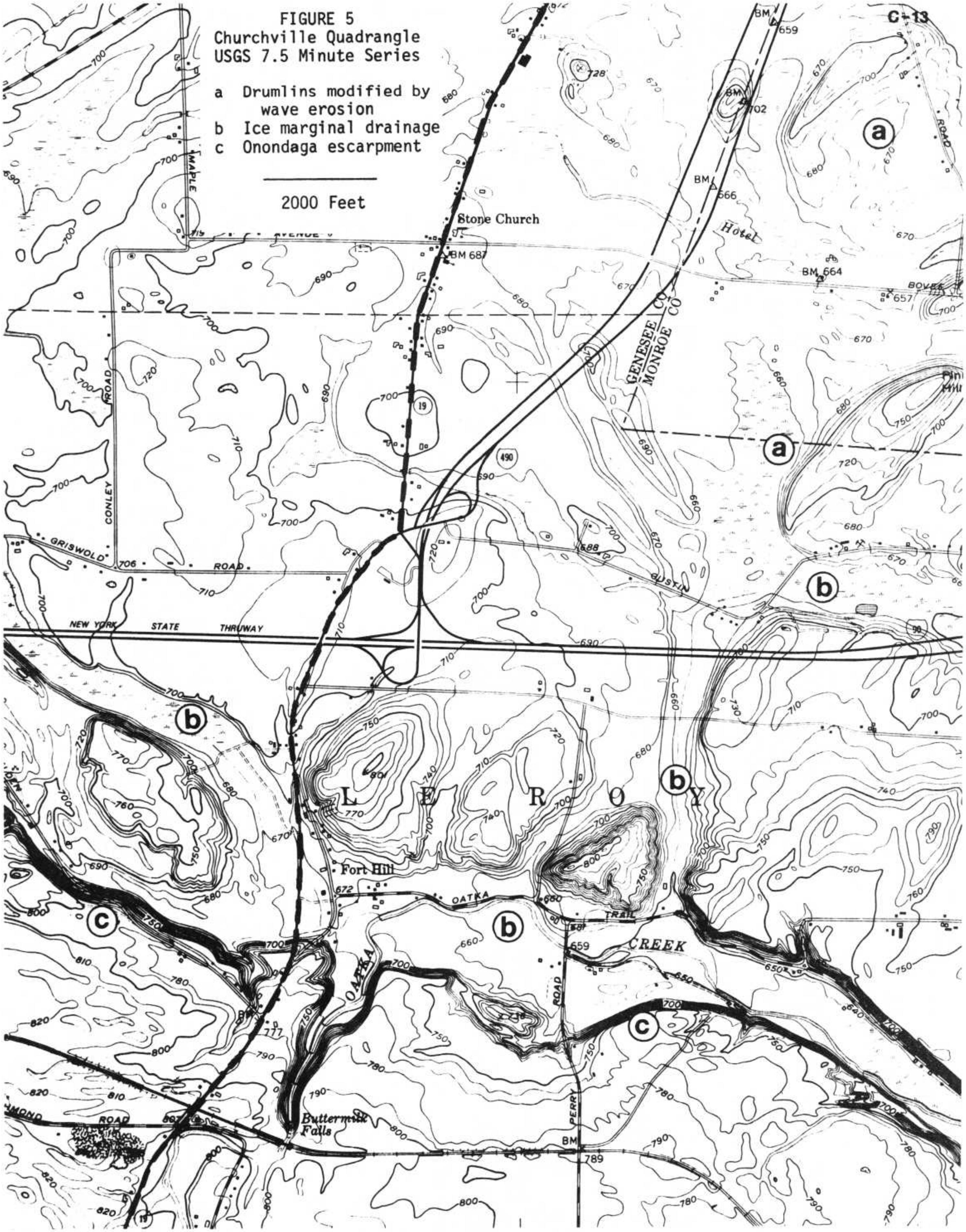
FIGURE 5
Churchville Quadrangle
USGS 7.5 Minute Series
a Drumlins modified by wave erosion
b Ice marginal drainage
c Onondaga escarpment
2000 Feet
Stone Church
Hotel
GENESEE CO
MONROE CO
CONLEY ROAD
MAPLE
GRISWOLD ROAD
NEW YORK STATE THRUWAY
AUSTIN
OATKA TRAIL
LE ROY
Fort Hill
OATKA CREEK
PERRY ROAD
Buttermilk Falls
BOVEE
a
b
c

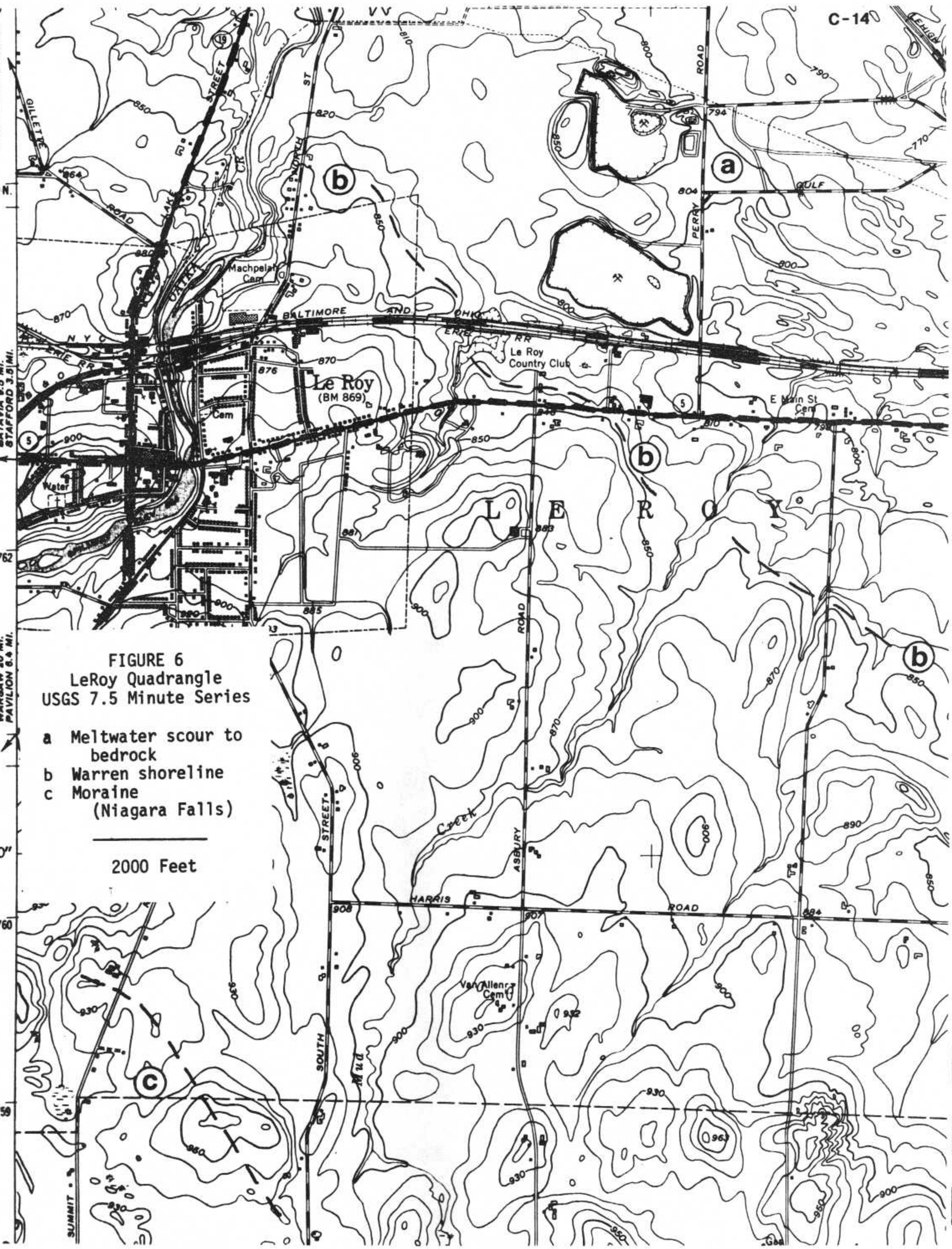

FIGURE 6
LeRoy Quadrangle
USGS 7.5 Minute Series

- a Meltwater scour to bedrock
- b Warren shoreline
- c Moraine (Niagara Falls)

2000 Feet

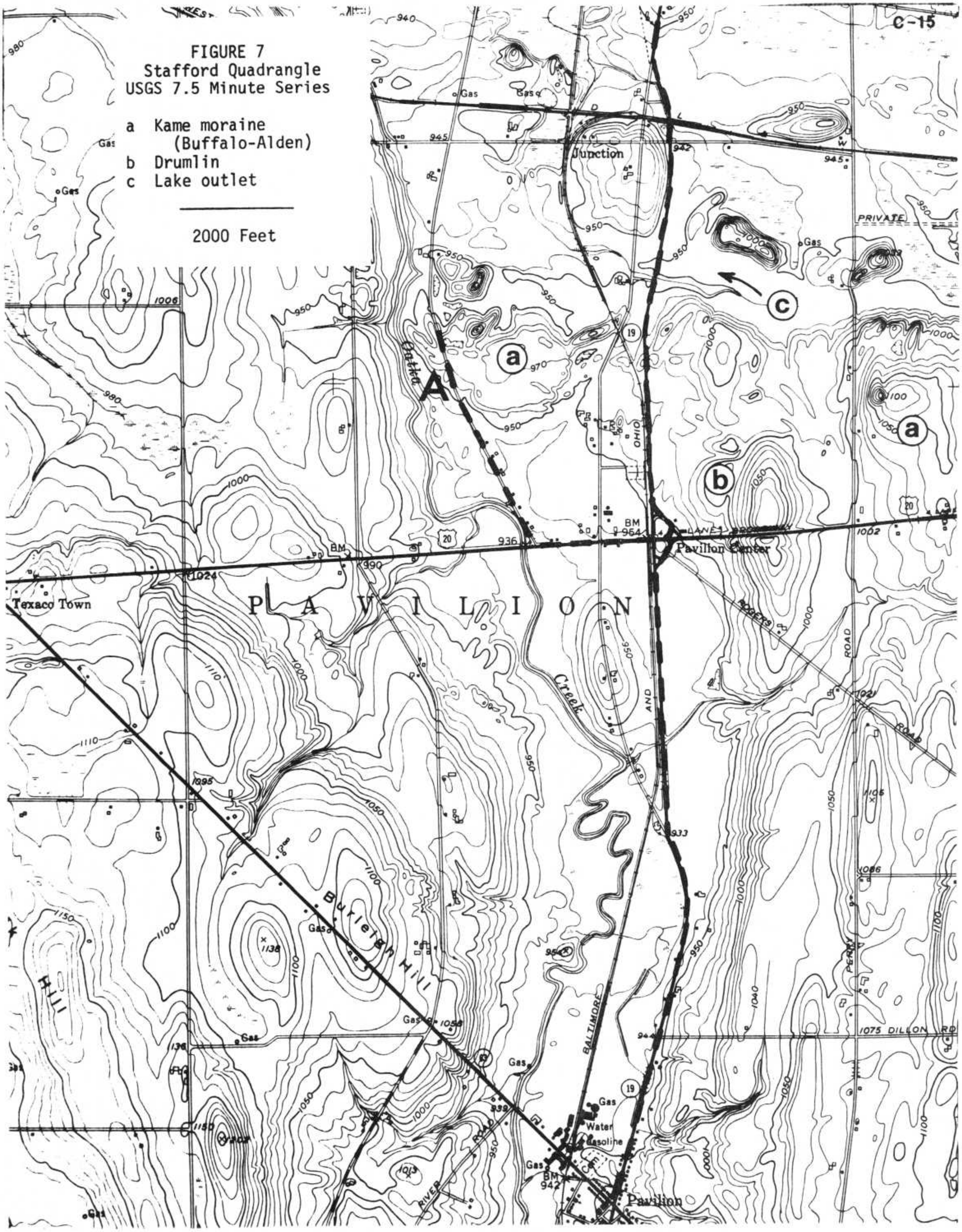

FIGURE 7
Stafford Quadrangle
USGS 7.5 Minute Series

a Kame moraine (Buffalo-Alden)
b Drumlin
c Lake outlet

2000 Feet

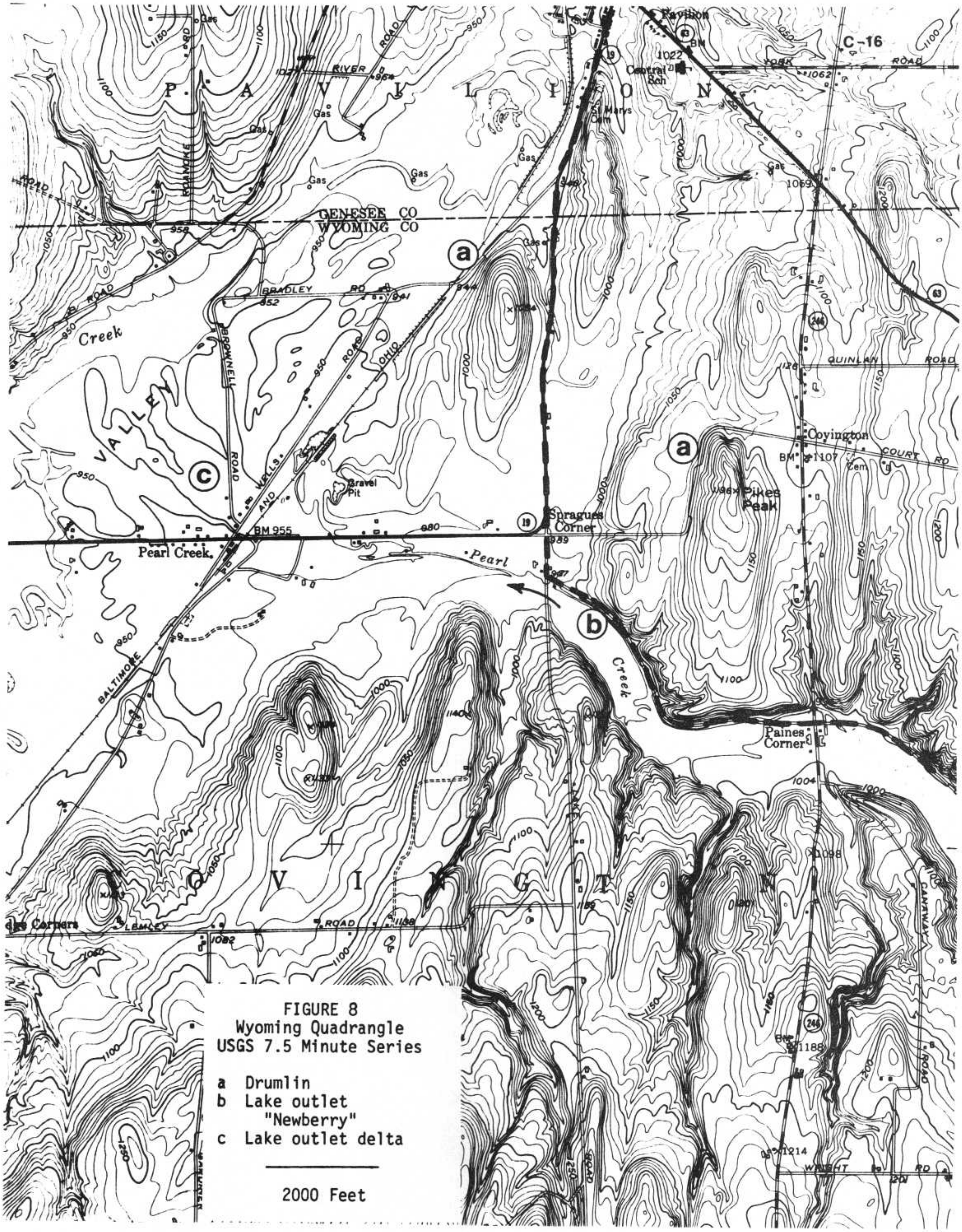

FIGURE 8
Wyoming Quadrangle
USGS 7.5 Minute Series

a Drumlin
b Lake outlet "Newberry"
c Lake outlet delta

2000 Feet


FIGURE 9
Leicester Quadrangle
USGS 7.5 Minute Series
a Alden moraine
b Lake outlet "Newberry"
c Shoreline "Newberry"
2000 Feet
Bennetts Corners
GENESEE CO
WYOMING CO
LIVINGSTON CO
Olivet Cem
WOLCOTT
Quinlan Corners
BOYD
Orrs Corners
ISHAM ROAD
COURT ROAD
BIG TREE ROAD
Peoria
COVINGTON
B
Mt Nash Cem
ROAD
Tryons Corners
WRIGHT ROAD
GRAND ROAD
ROOD ROAD
KENDALL ROAD
BARBER ROAD

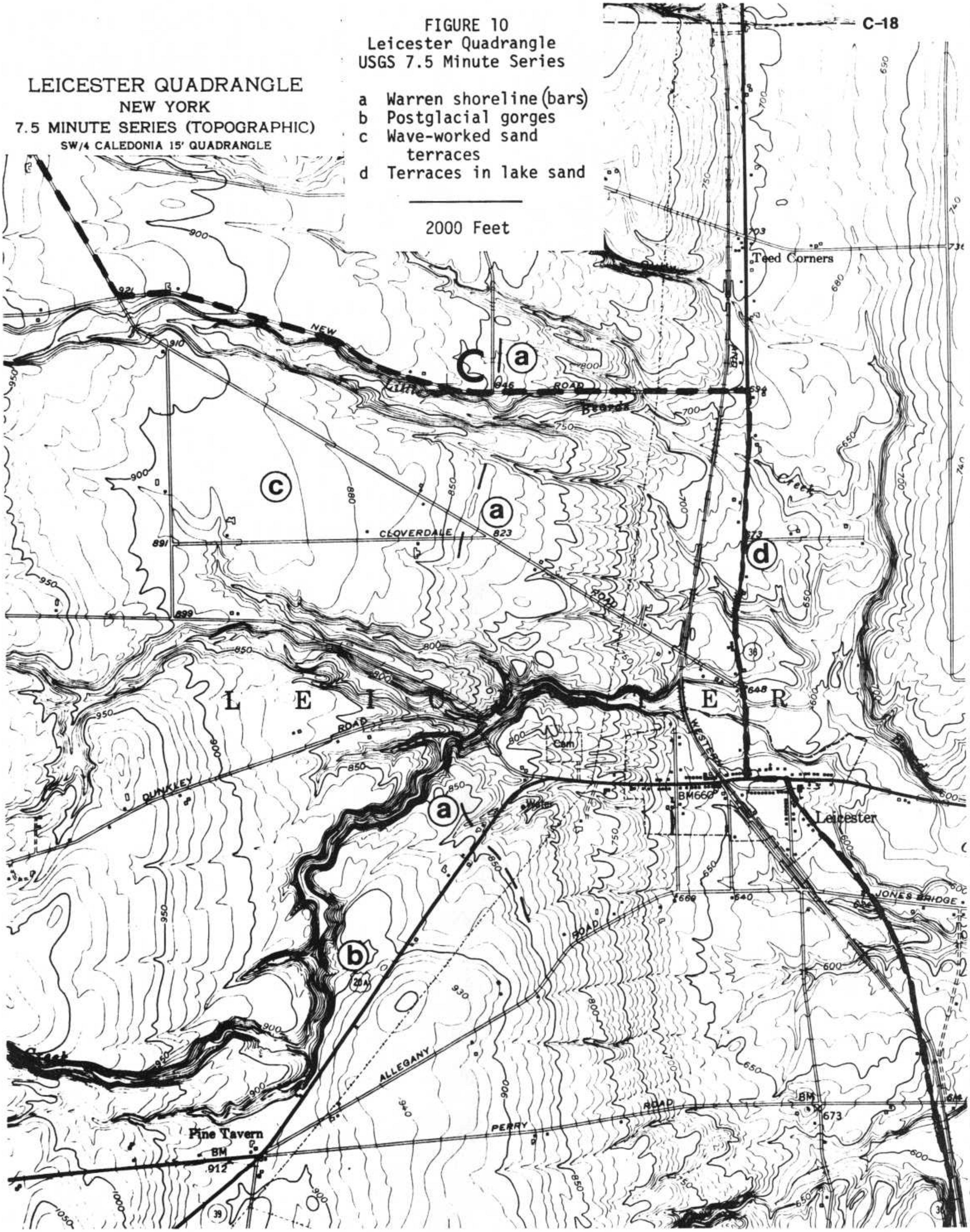

FIGURE 10
Leicester Quadrangle
USGS 7.5 Minute Series

a Warren shoreline (bars)
b Postglacial gorges
c Wave-worked sand terraces
d Terraces in lake sand

2000 Feet

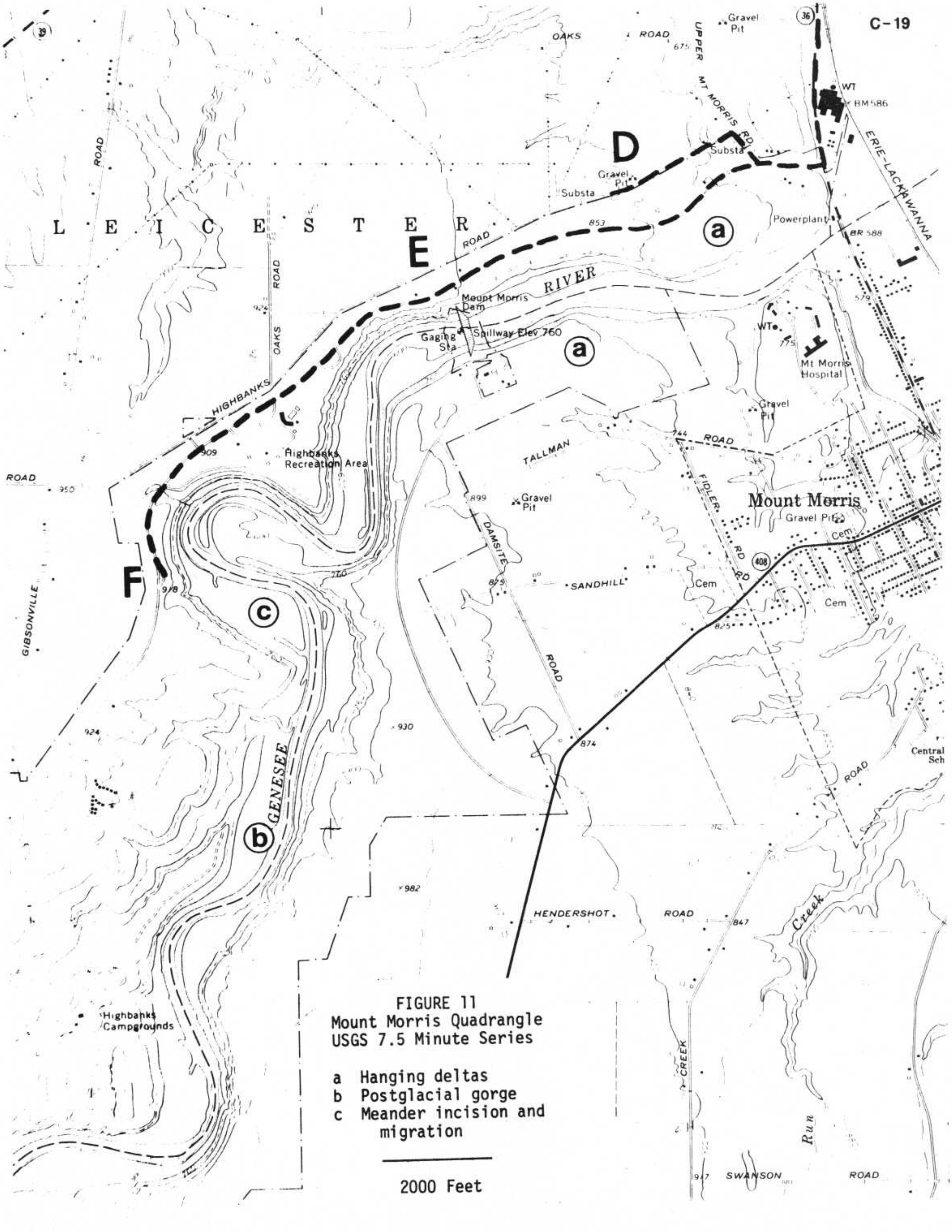

FIGURE 11
Mount Morris Quadrangle
USGS 7.5 Minute Series

a Hanging deltas
b Postglacial gorge
c Meander incision and migration

2000 Feet

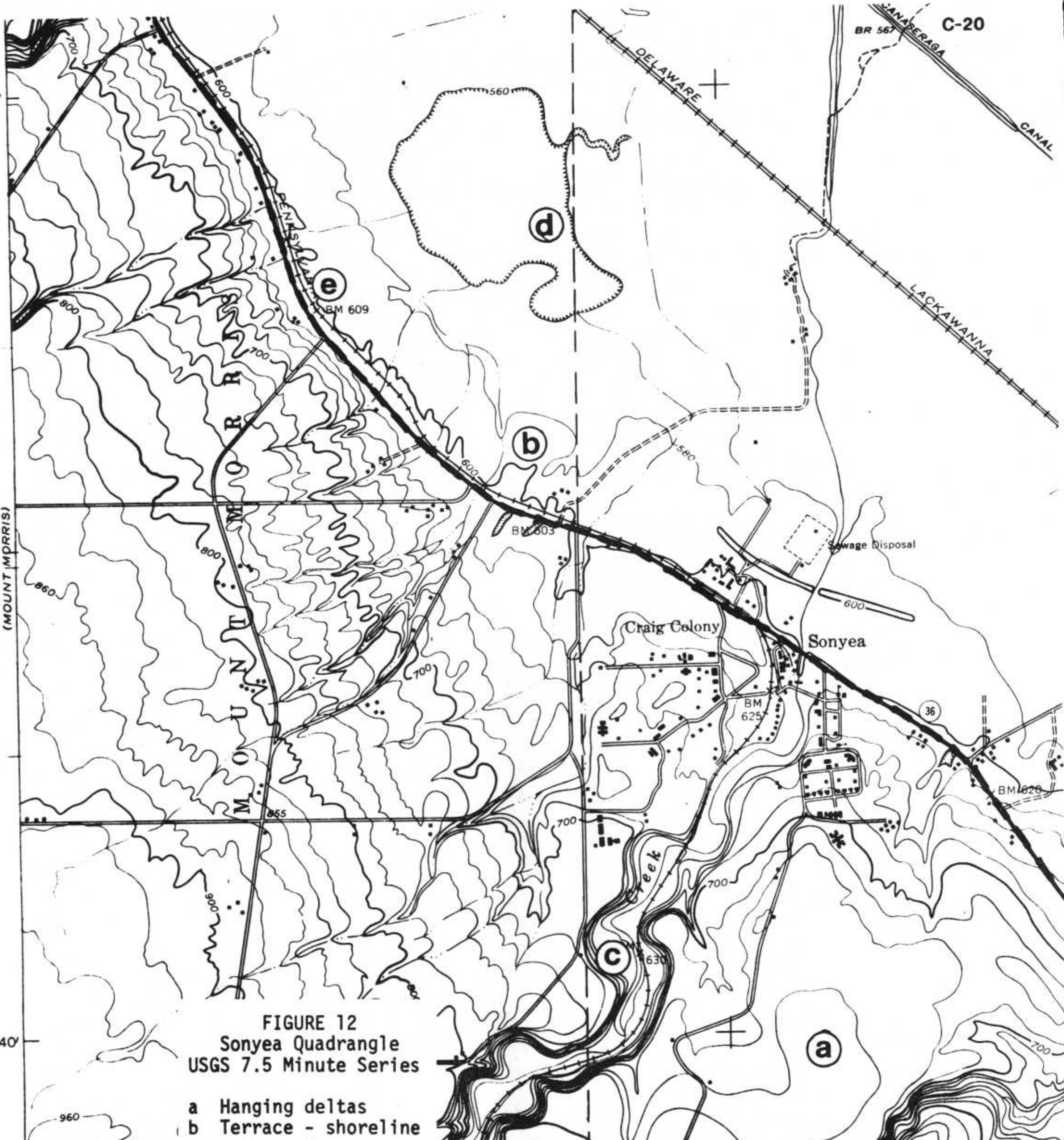

FIGURE 12
Sonyea Quadrangle
USGS 7.5 Minute Series

- a Hanging deltas
- b Terrace - shoreline remnants
- c Postglacial stream incision in deltas
- d Floodplain on lacustrine sediments (8000-11,000 BP)
- e Genesee valley canal next to railroad

2000 Feet

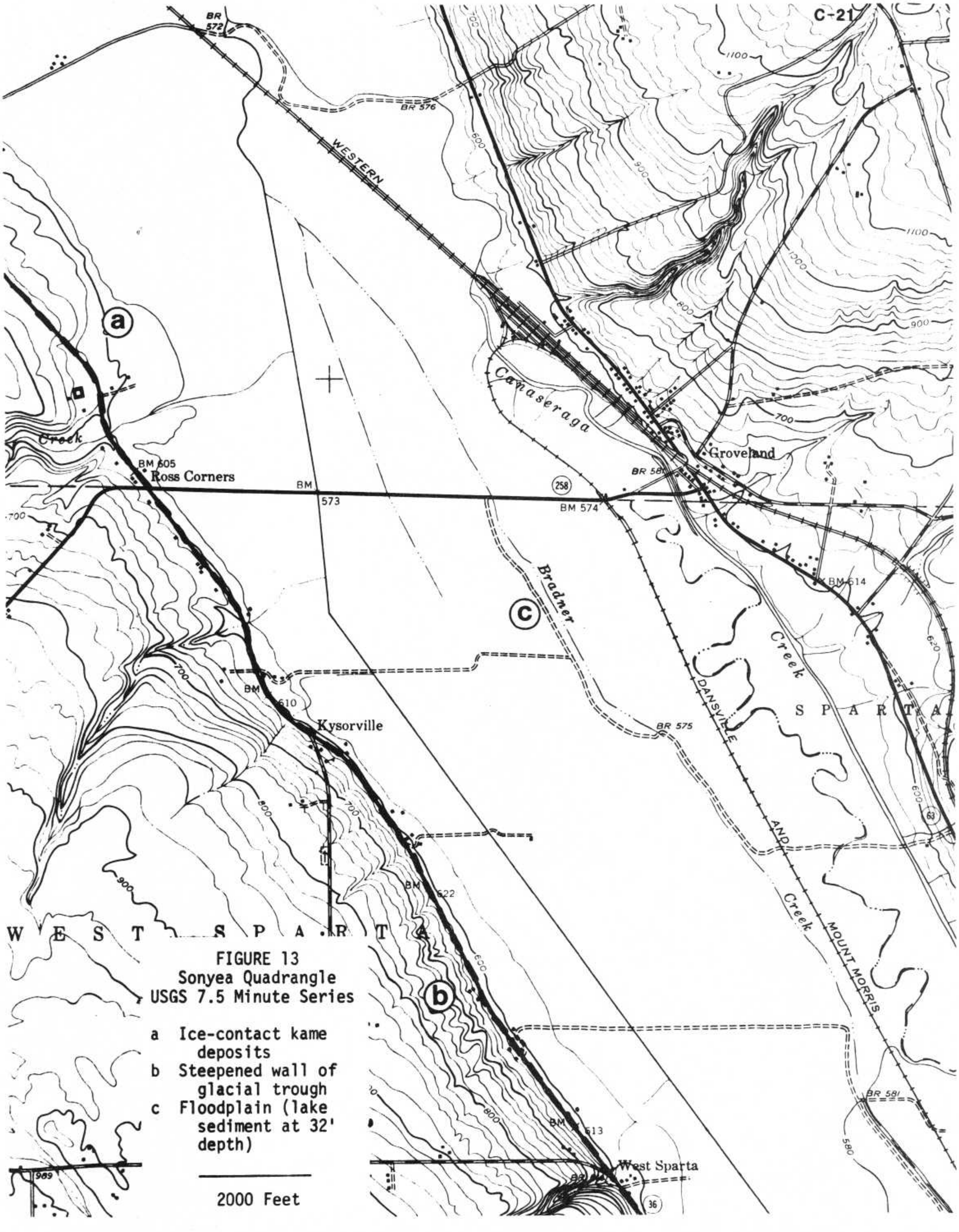

FIGURE 13
Sonyea Quadrangle
USGS 7.5 Minute Series

a Ice-contact kame deposits
b Steepened wall of glacial trough
c Floodplain (lake sediment at 32' depth)

2000 Feet

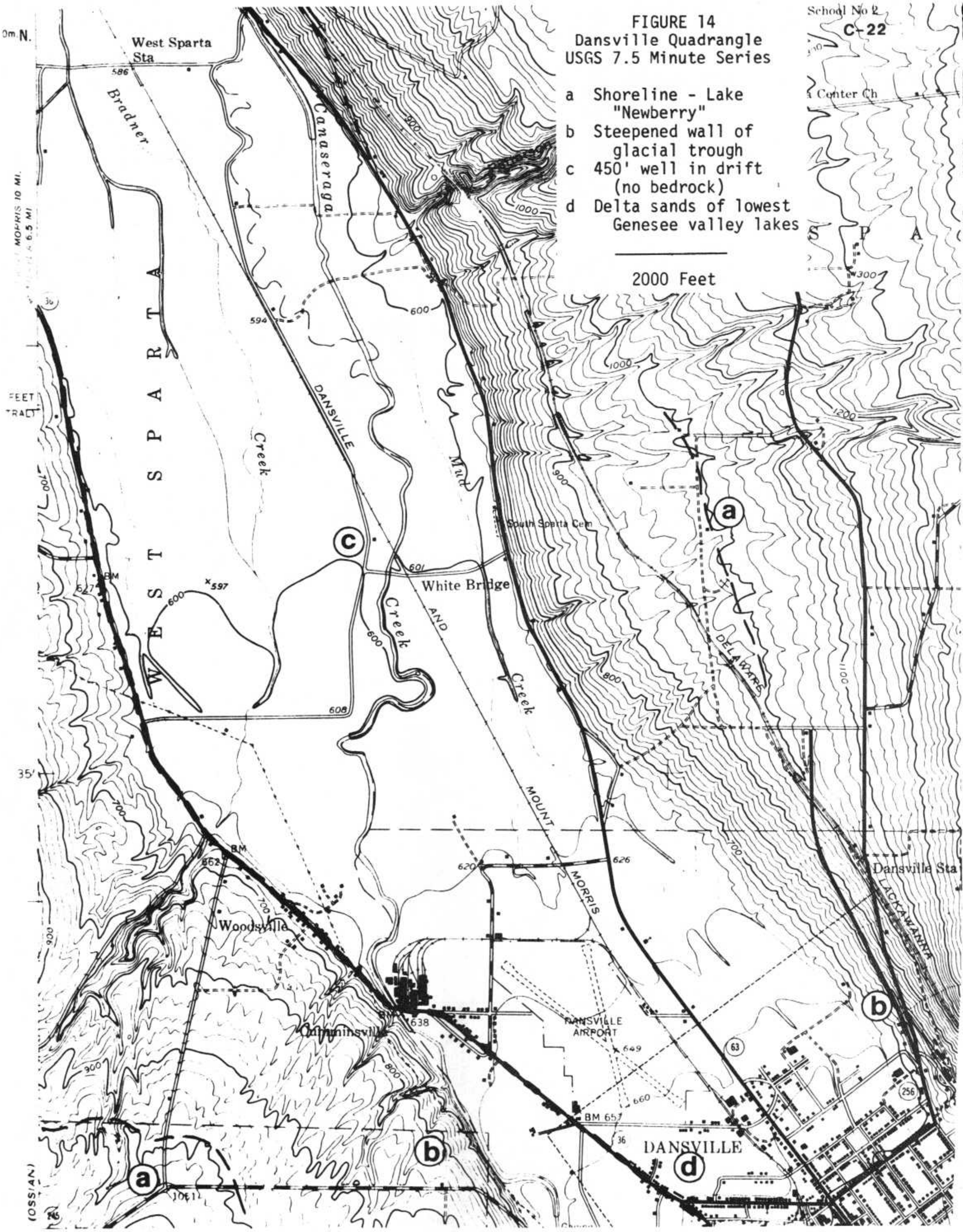

FIGURE 14
Dansville Quadrangle
USGS 7.5 Minute Series

a Shoreline - Lake "Newberry"
b Steepened wall of glacial trough
c 450' well in drift (no bedrock)
d Delta sands of lowest Genesee valley lakes

2000 Feet

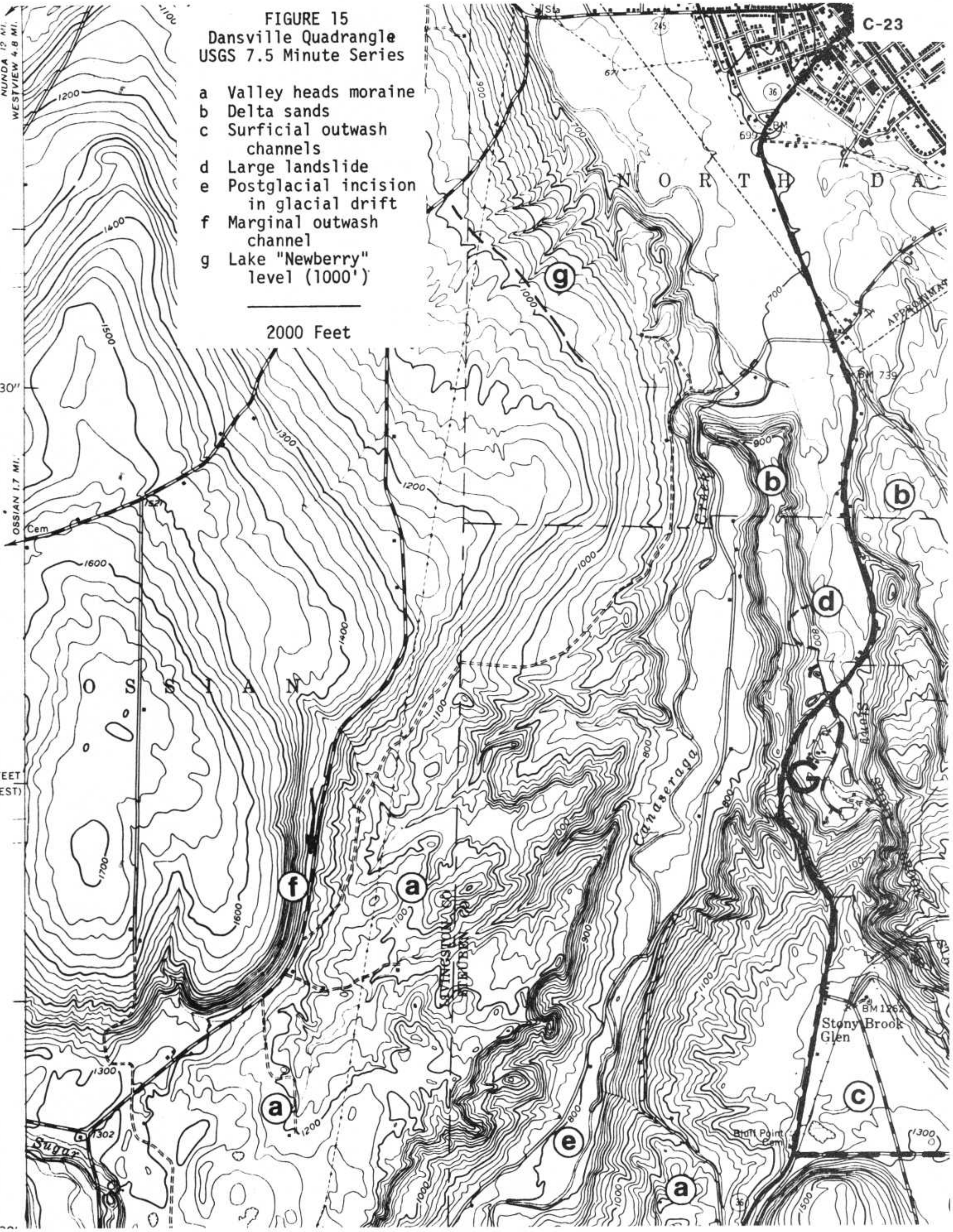

FIGURE 15
Dansville Quadrangle
USGS 7.5 Minute Series

- a Valley heads moraine
- b Delta sands
- c Surficial outwash channels
- d Large landslide
- e Postglacial incision in glacial drift
- f Marginal outwash channel
- g Lake "Newberry" level (1000')

2000 Feet

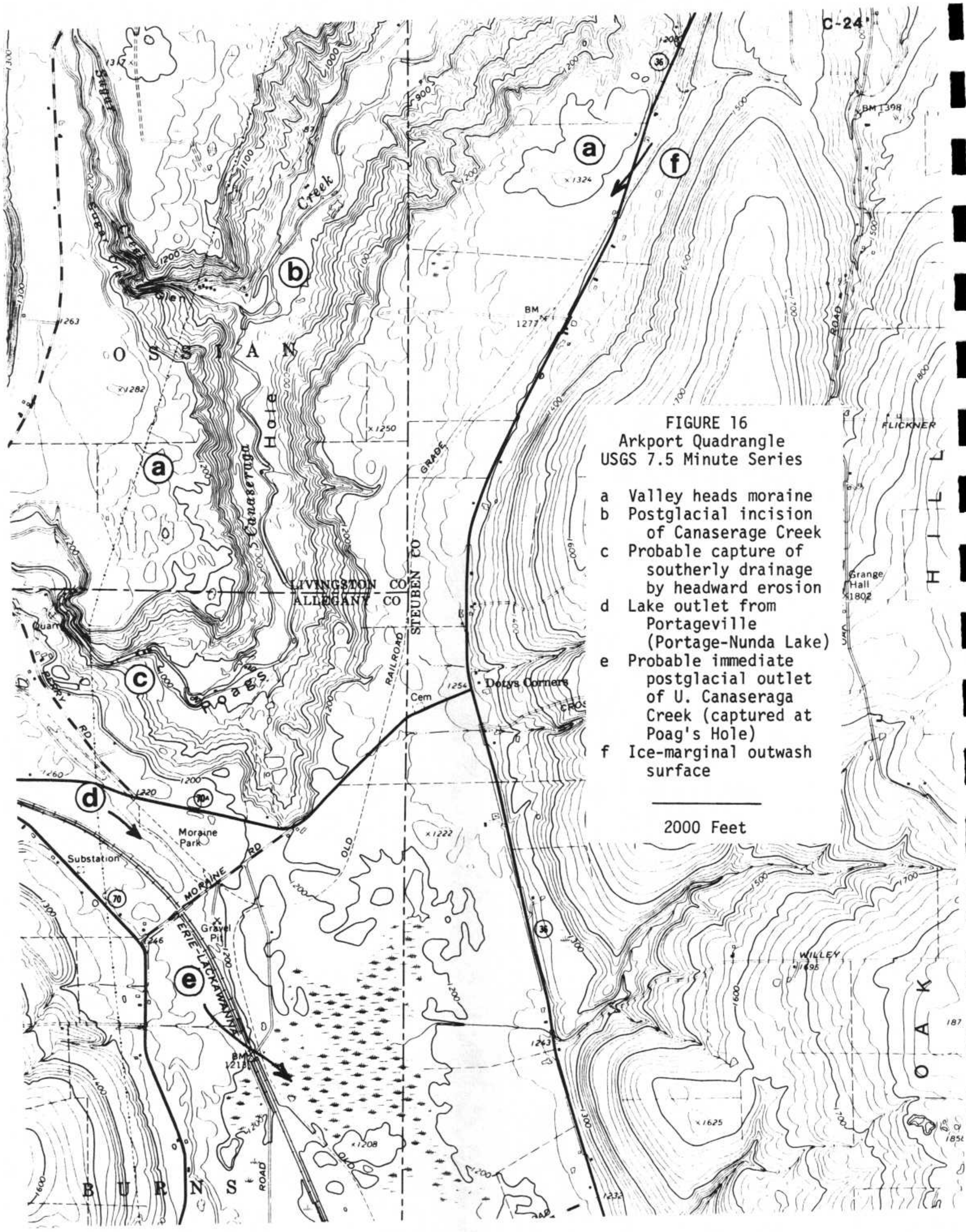

FIGURE 16
Arkport Quadrangle
USGS 7.5 Minute Series

a Valley heads moraine
b Postglacial incision of Canaserage Creek
c Probable capture of southerly drainage by headward erosion
d Lake outlet from Portageville (Portage-Nunda Lake)
e Probable immediate postglacial outlet of U. Canaseraga Creek (captured at Poag's Hole)
f Ice-marginal outwash surface

2000 Feet

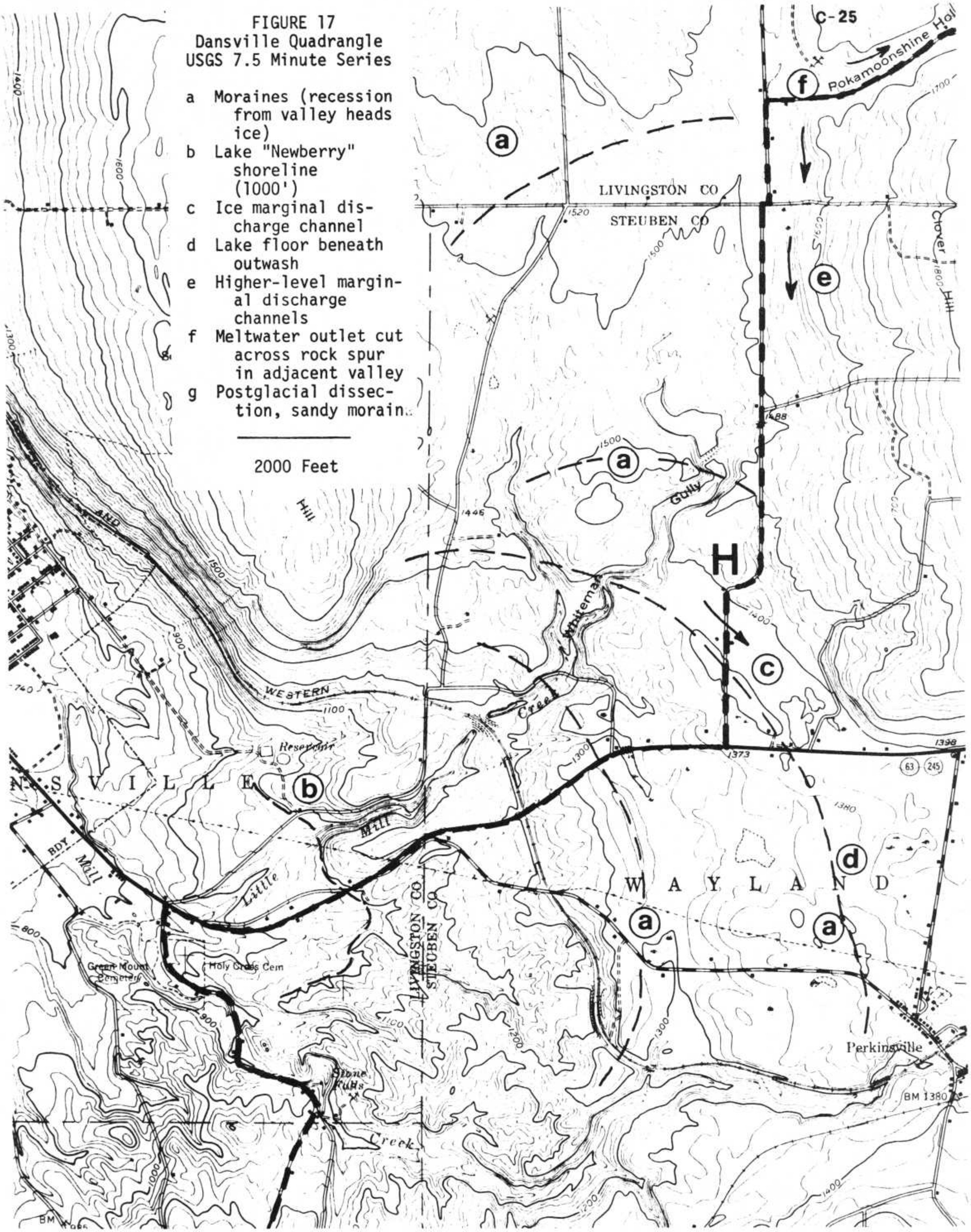

FIGURE 17
Dansville Quadrangle
USGS 7.5 Minute Series

- a Moraines (recession from valley heads ice)
- b Lake "Newberry" shoreline (1000')
- c Ice marginal discharge channel
- d Lake floor beneath outwash
- e Higher-level marginal discharge channels
- f Meltwater outlet cut across rock spur in adjacent valley
- g Postglacial dissection, sandy morain.

2000 Feet

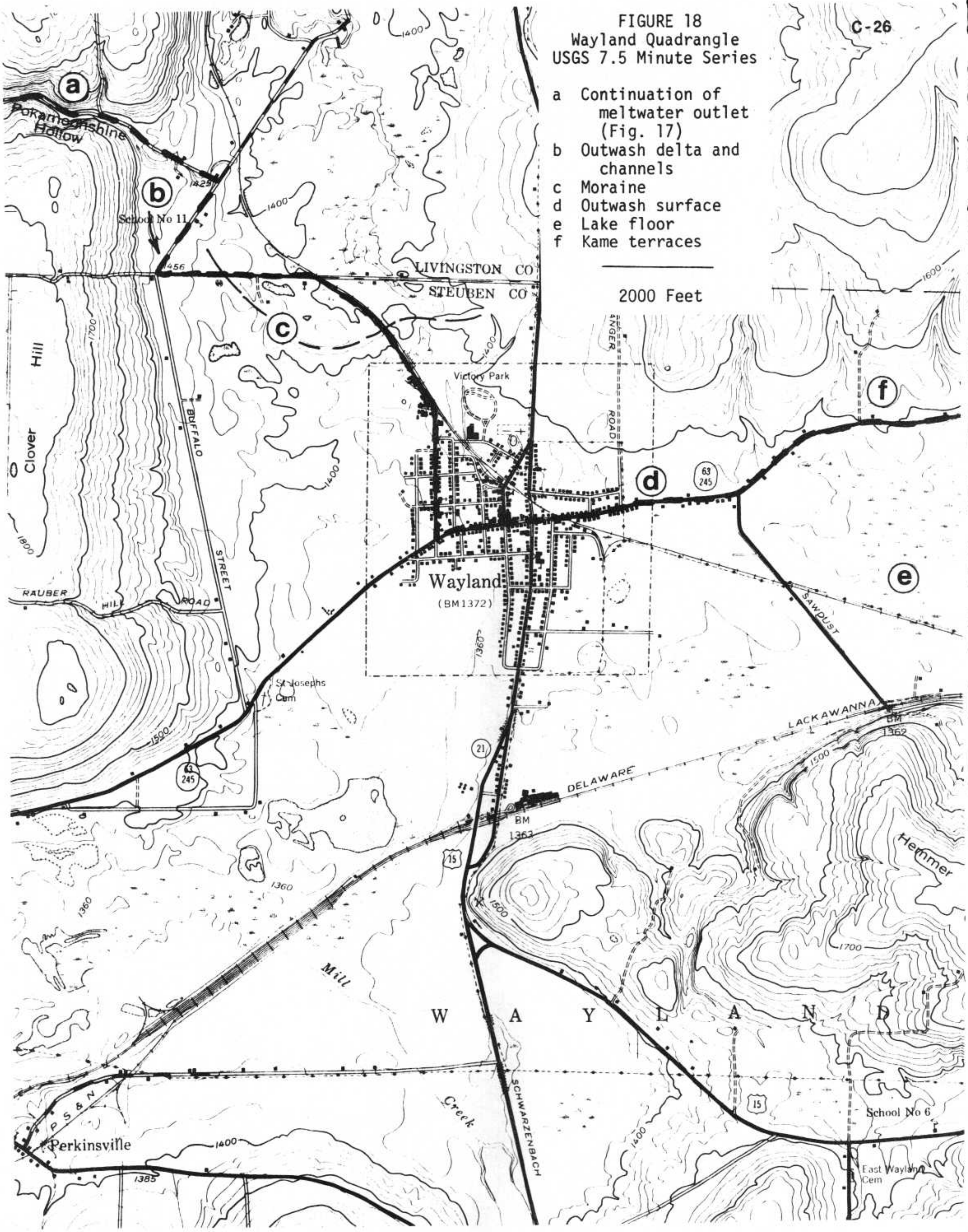

FIGURE 18
Wayland Quadrangle
USGS 7.5 Minute Series

- a Continuation of meltwater outlet (Fig. 17)
- b Outwash delta and channels
- c Moraine
- d Outwash surface
- e Lake floor
- f Kame terraces

2000 Feet

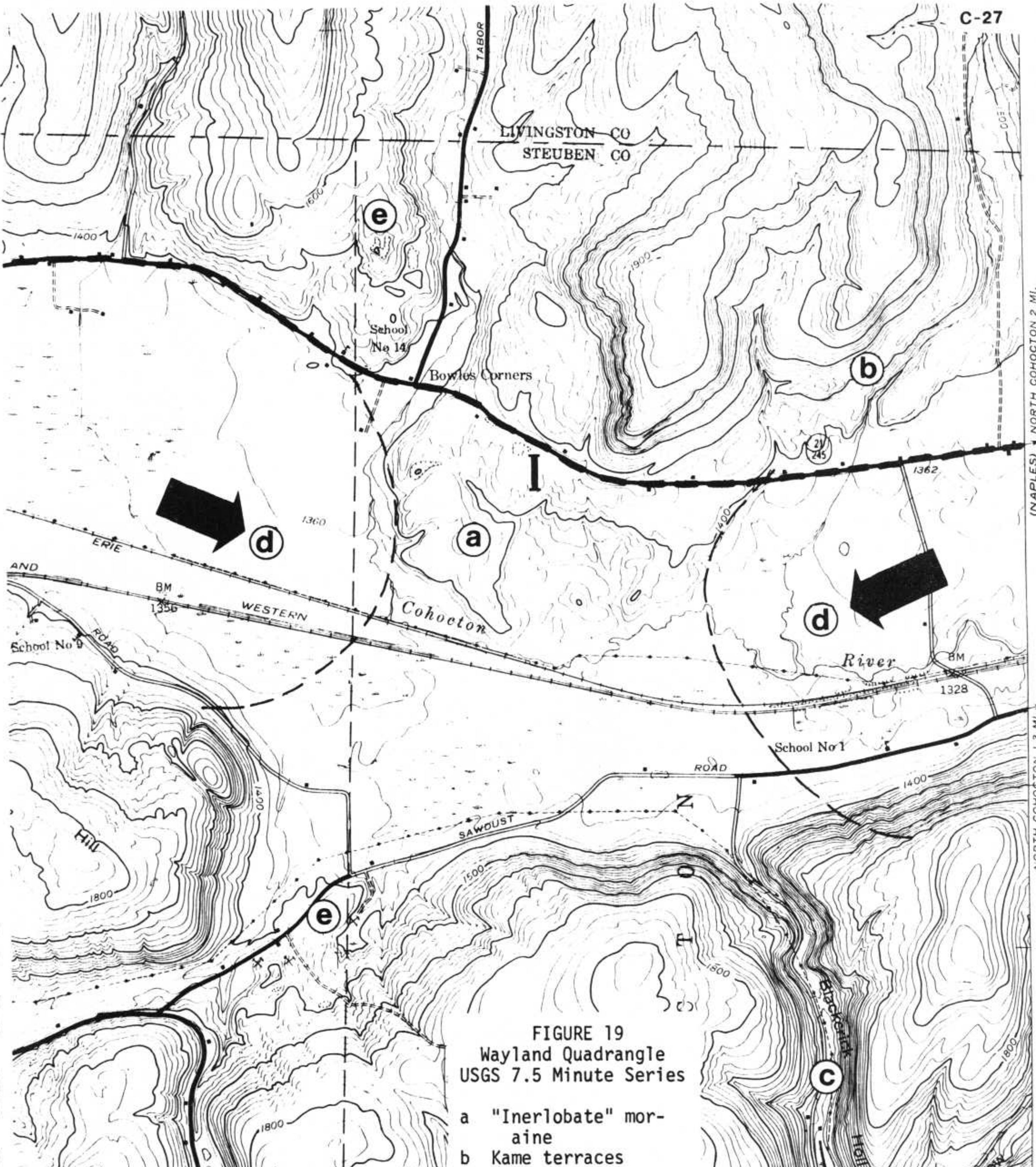

FIGURE 19
Wayland Quadrangle
USGS 7.5 Minute Series

a "Inerlobate" moraine
b Kame terraces
c Lake outlet for lake bet. 2 ice lobes
d Inferred ice margins and flow
e Kame terrace-delta

2000 Feet

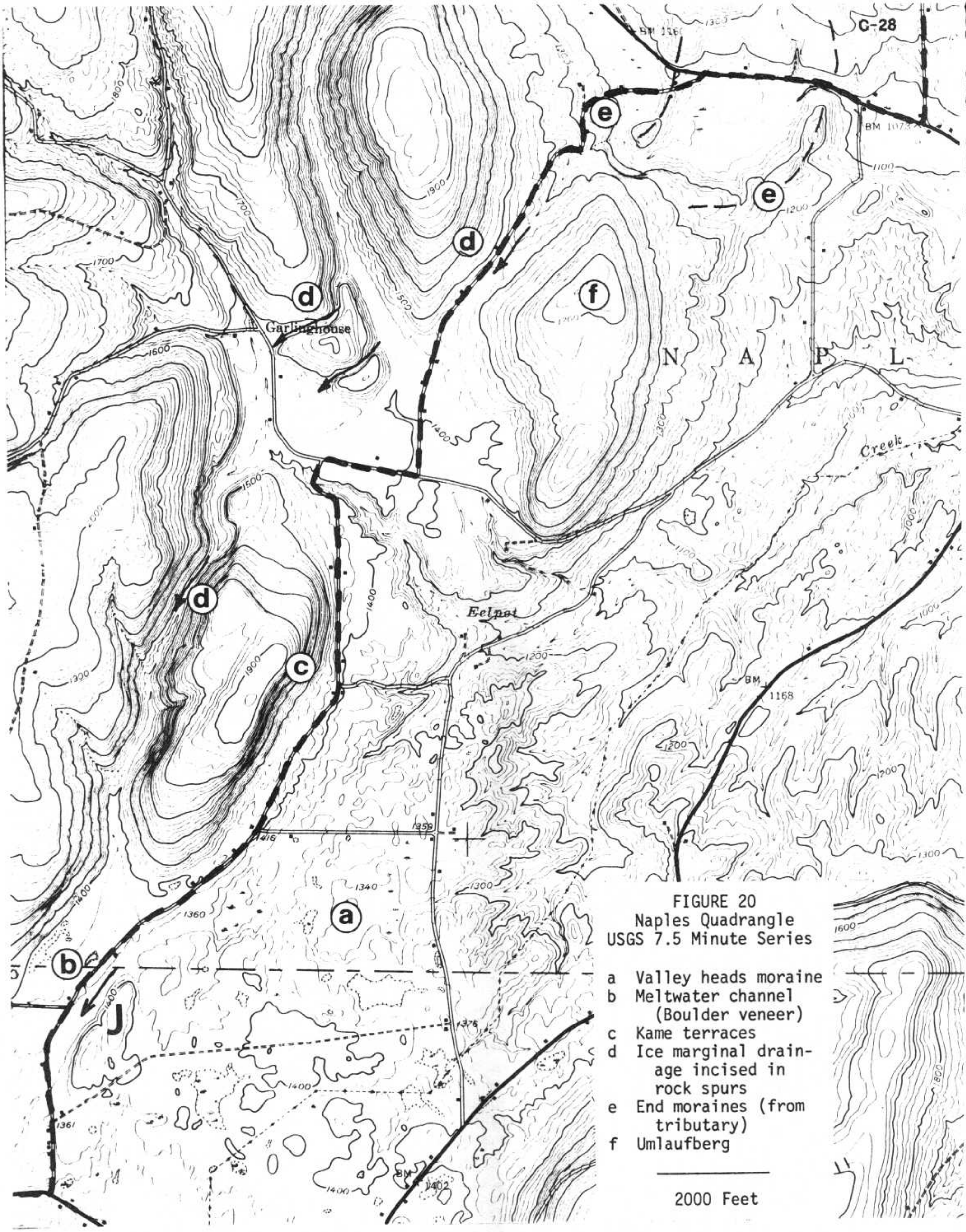

FIGURE 20
Naples Quadrangle
USGS 7.5 Minute Series

a Valley heads moraine
b Meltwater channel (Boulder veneer)
c Kame terraces
d Ice marginal drainage incised in rock spurs
e End moraines (from tributary)
f Umlaufberg

2000 Feet

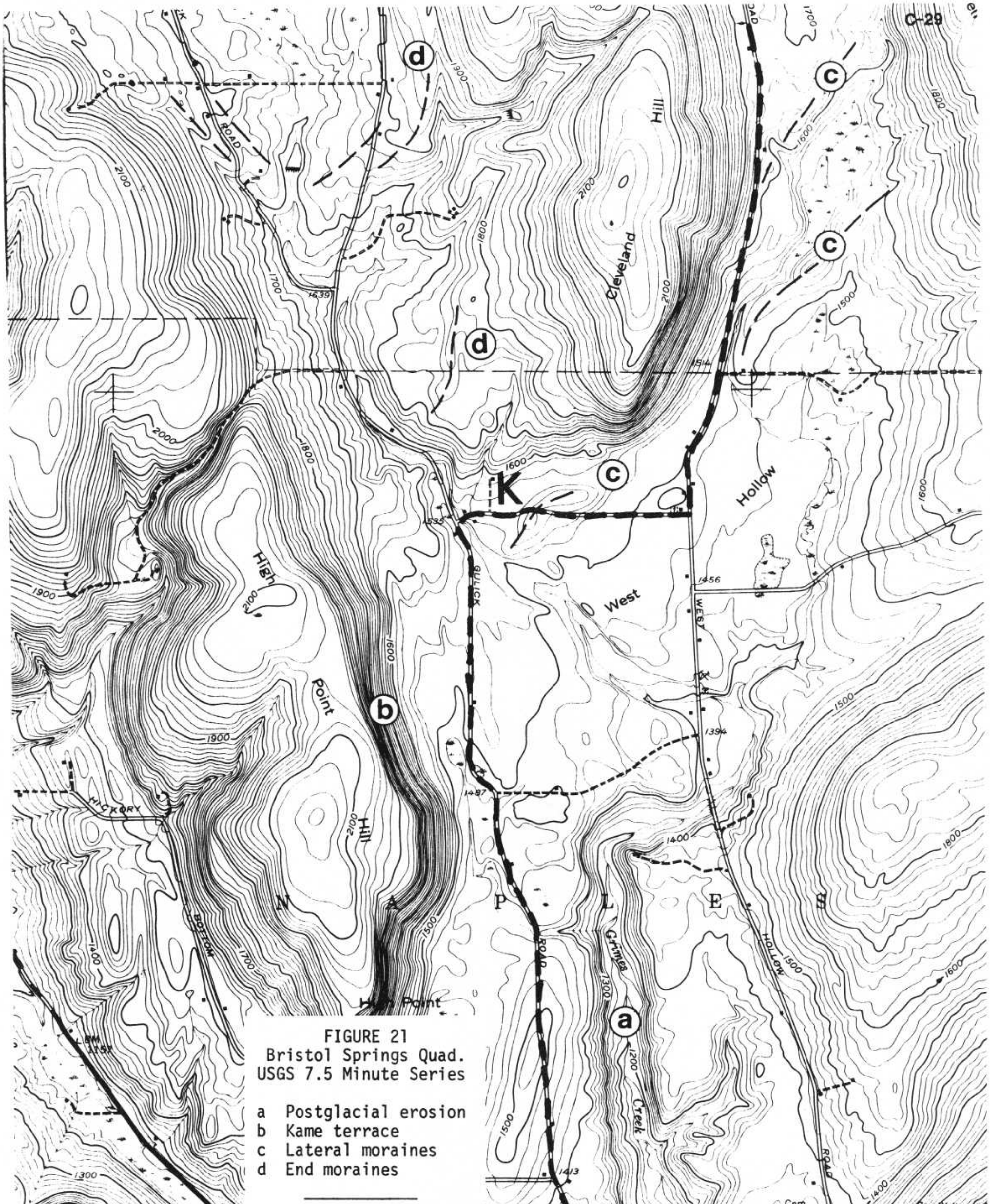

FIGURE 21
Bristol Springs Quad.
USGS 7.5 Minute Series

a Postglacial erosion
b Kame terrace
c Lateral moraines
d End moraines

2000 Feet

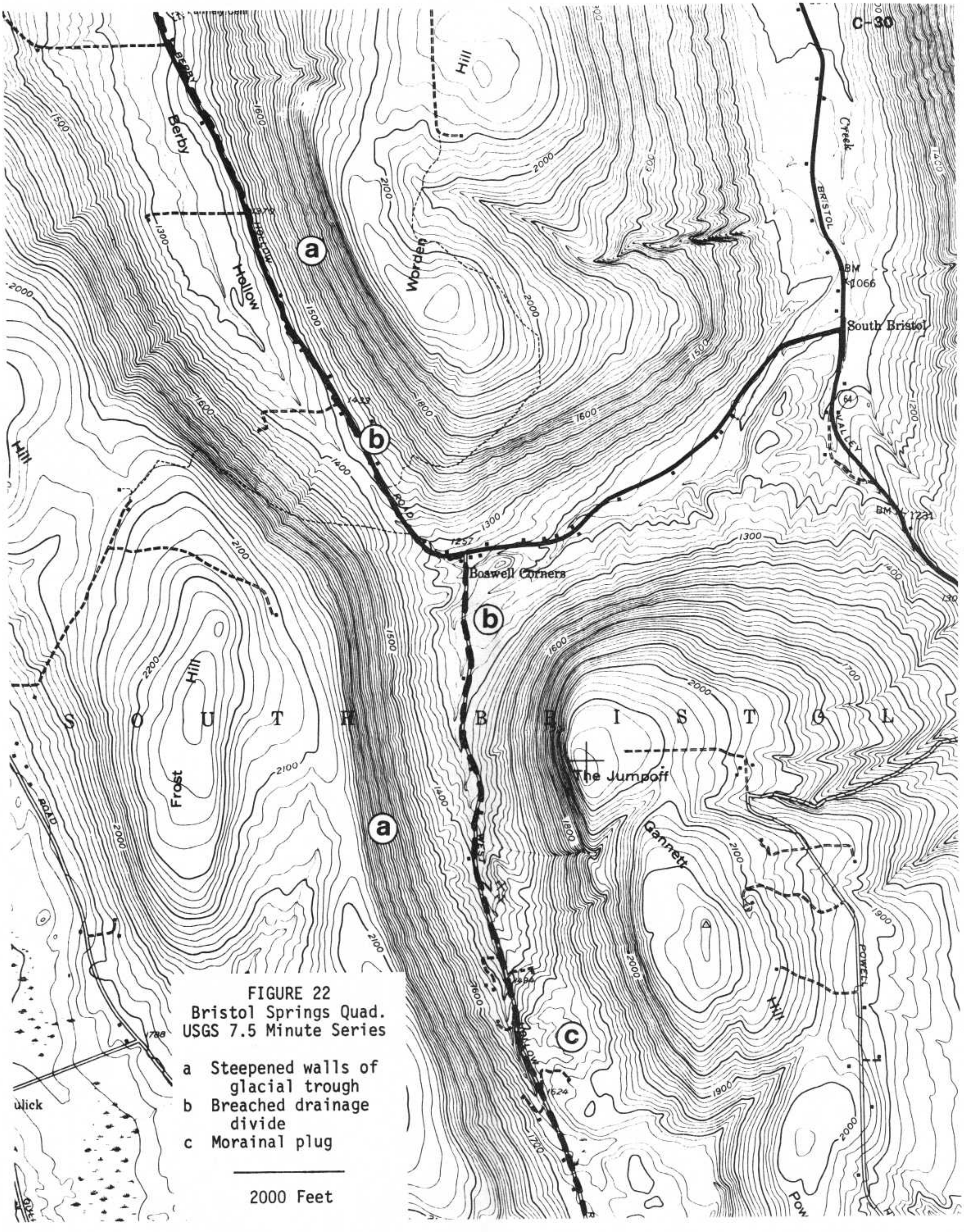

FIGURE 22
Bristol Springs Quad.
USGS 7.5 Minute Series

a Steepened walls of glacial trough
b Breached drainage divide
c Morainal plug

2000 Feet

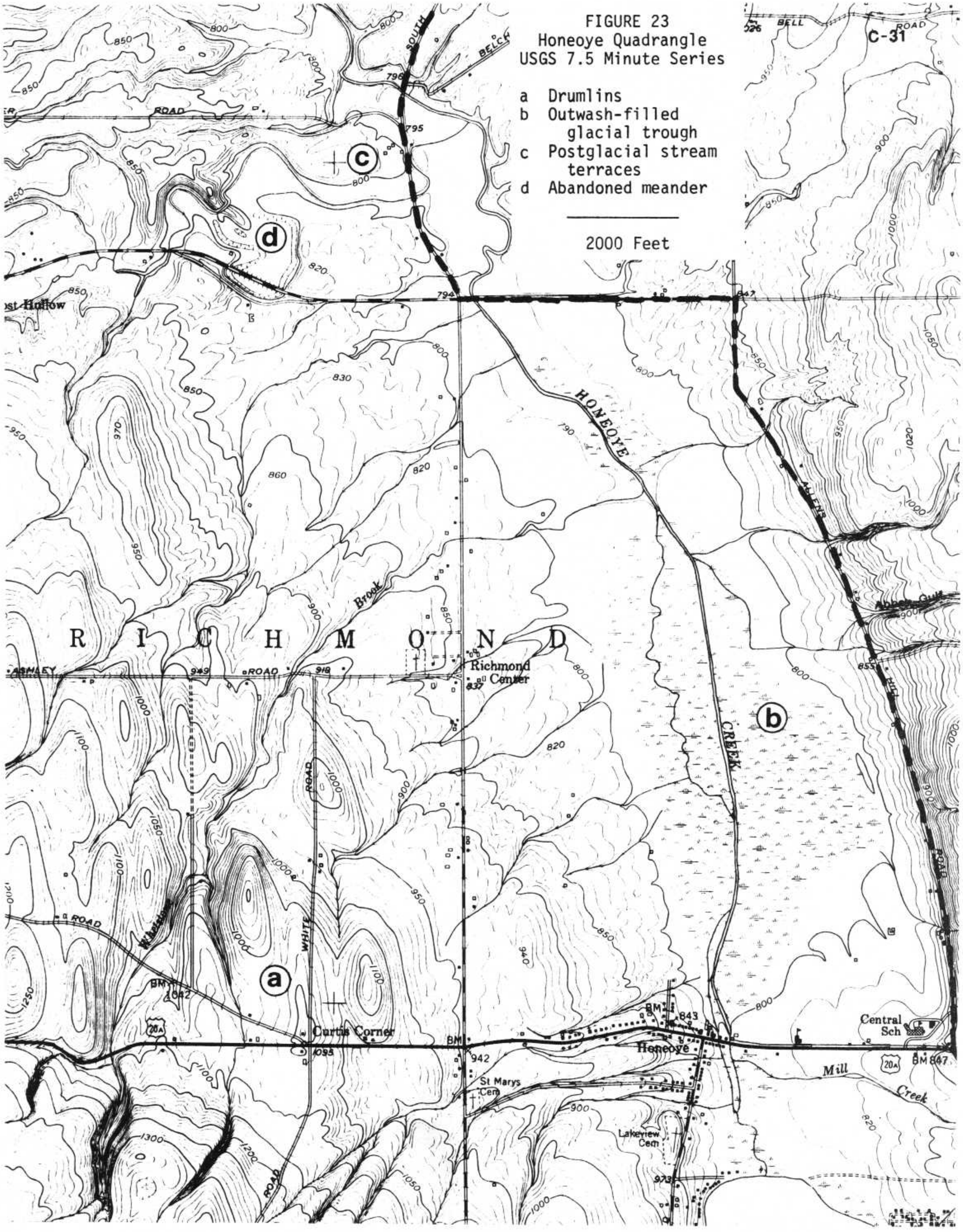

FIGURE 23
Honeoye Quadrangle
USGS 7.5 Minute Series

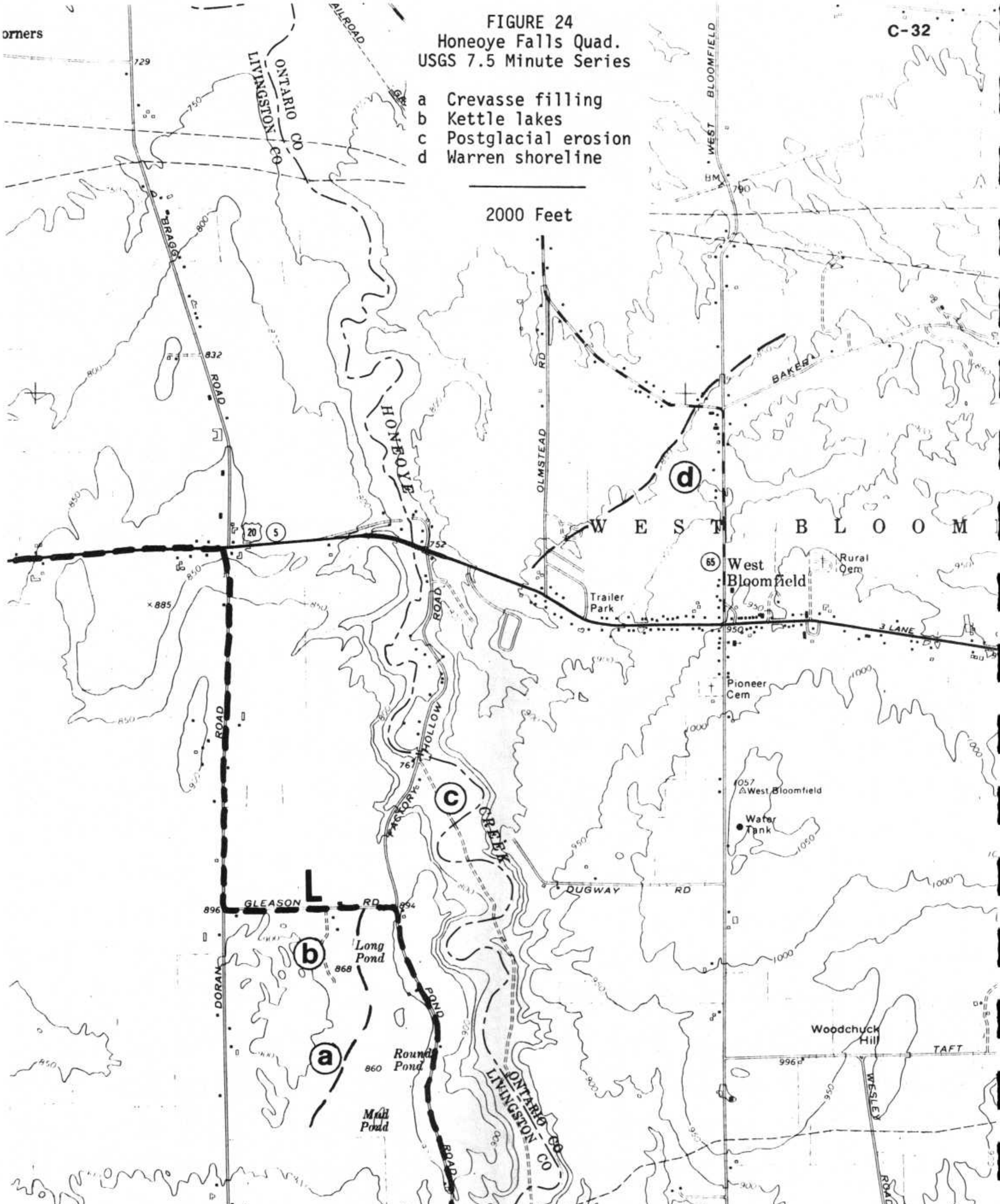

FIGURE 24
Honeoye Falls Quad.
USGS 7.5 Minute Series

a Crevasse filling
b Kettle lakes
c Postglacial erosion
d Warren shoreline

2000 Feet

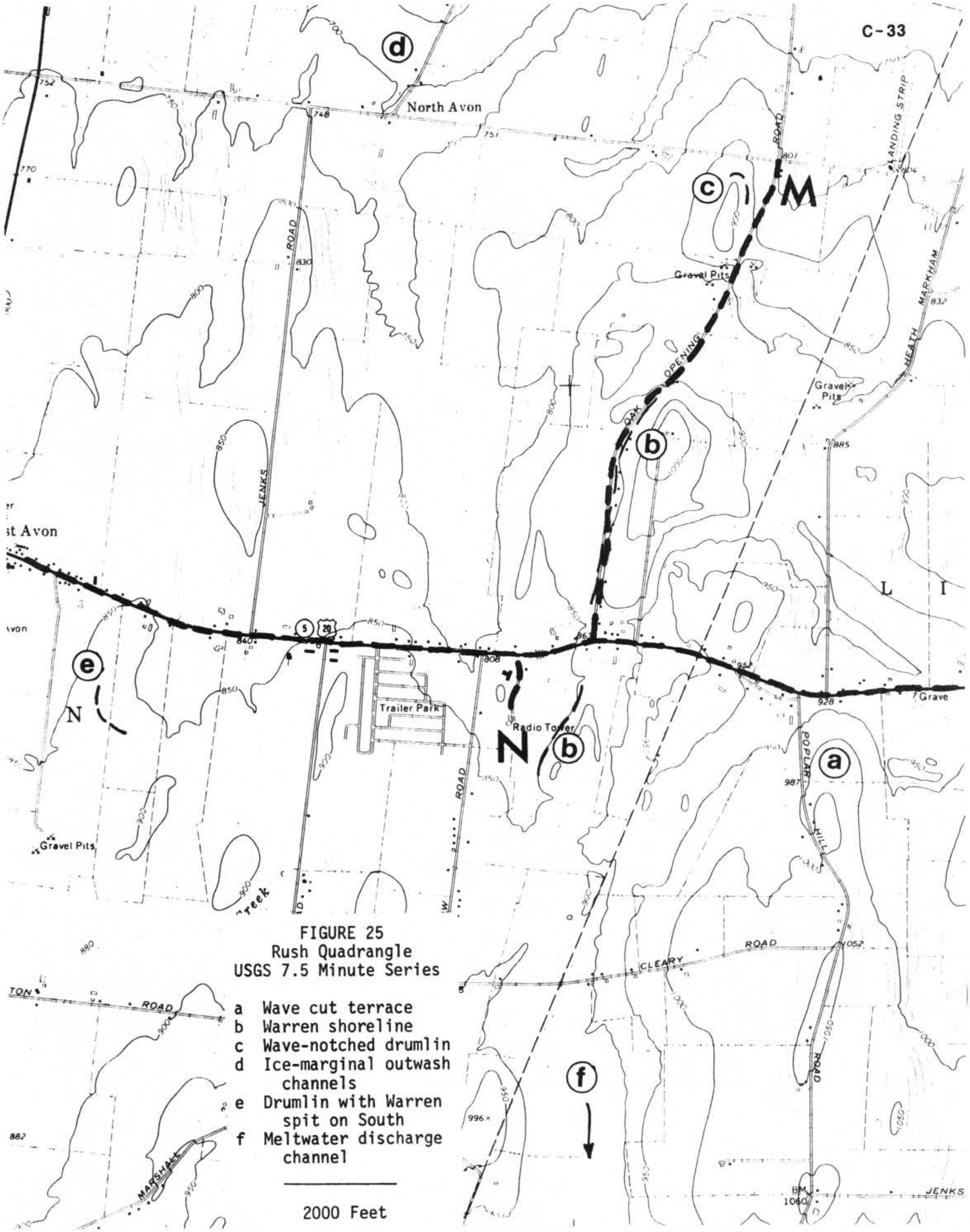

FIGURE 25
Rush Quadrangle
USGS 7.5 Minute Series

- a Wave cut terrace
- b Warren shoreline
- c Wave-notched drumlin
- d Ice-marginal outwash channels
- e Drumlin with Warren spit on South
- f Meltwater discharge channel

2000 Feet

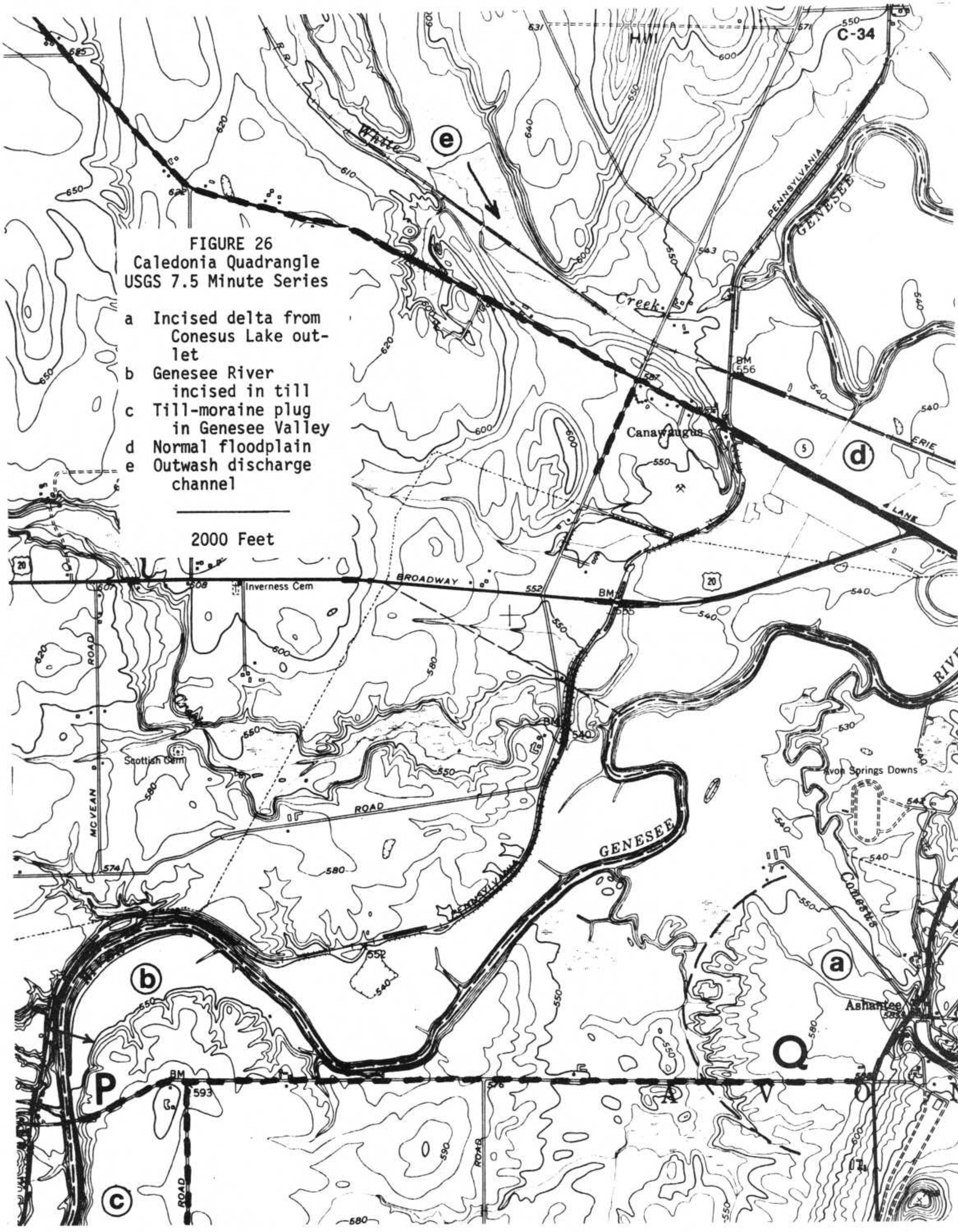

FIGURE 26
Caledonia Quadrangle
USGS 7.5 Minute Series

- a Incised delta from Conesus Lake outlet
- b Genesee River incised in till
- c Till-moraine plug in Genesee Valley
- d Normal floodplain
- e Outwash discharge channel

2000 Feet

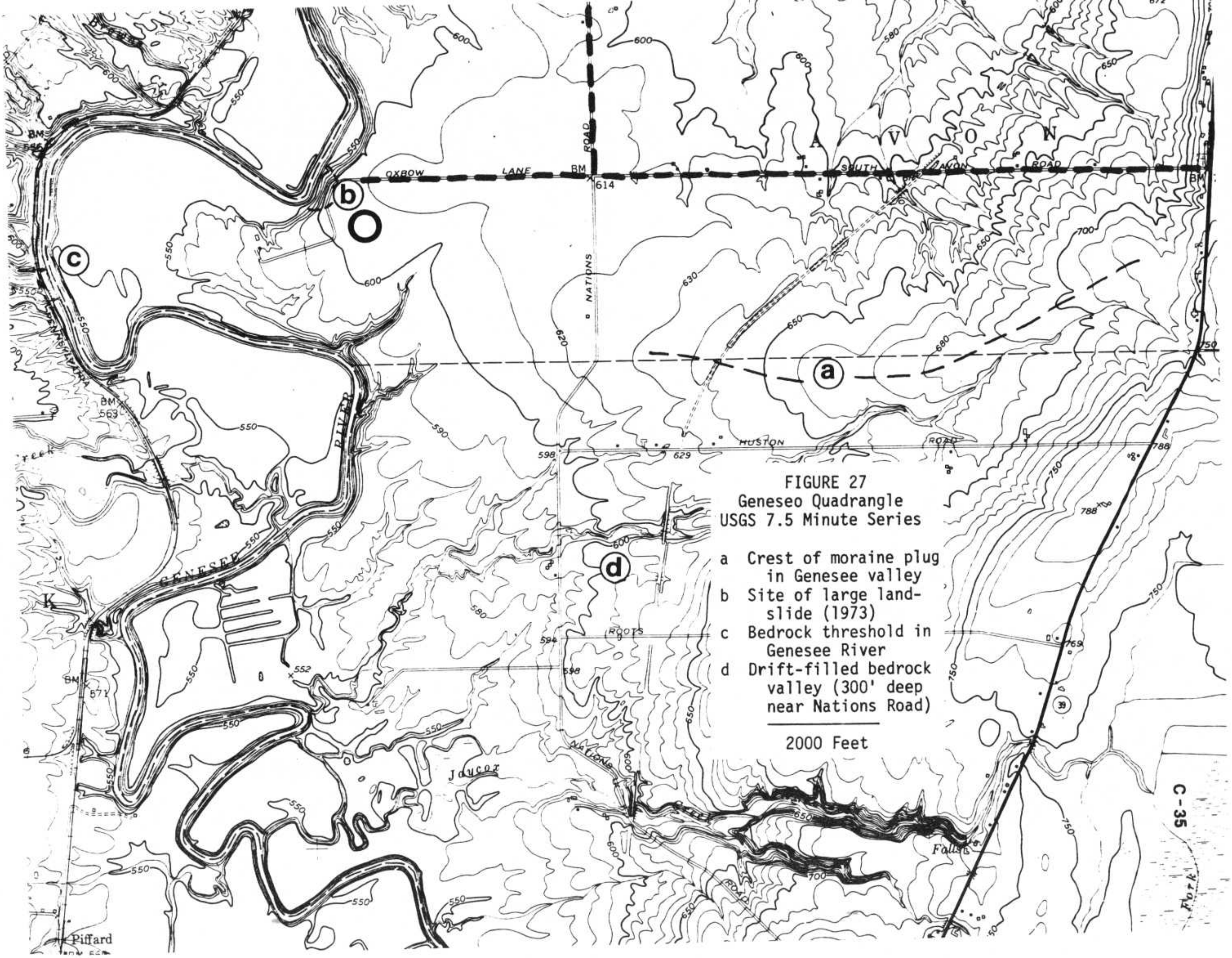

FIGURE 27
Geneseo Quadrangle
USGS 7.5 Minute Series

a Crest of moraine plug in Genesee valley
b Site of large land-slide (1973)
c Bedrock threshold in Genesee River
d Drift-filled bedrock valley (300' deep near Nations Road)

2000 Feet

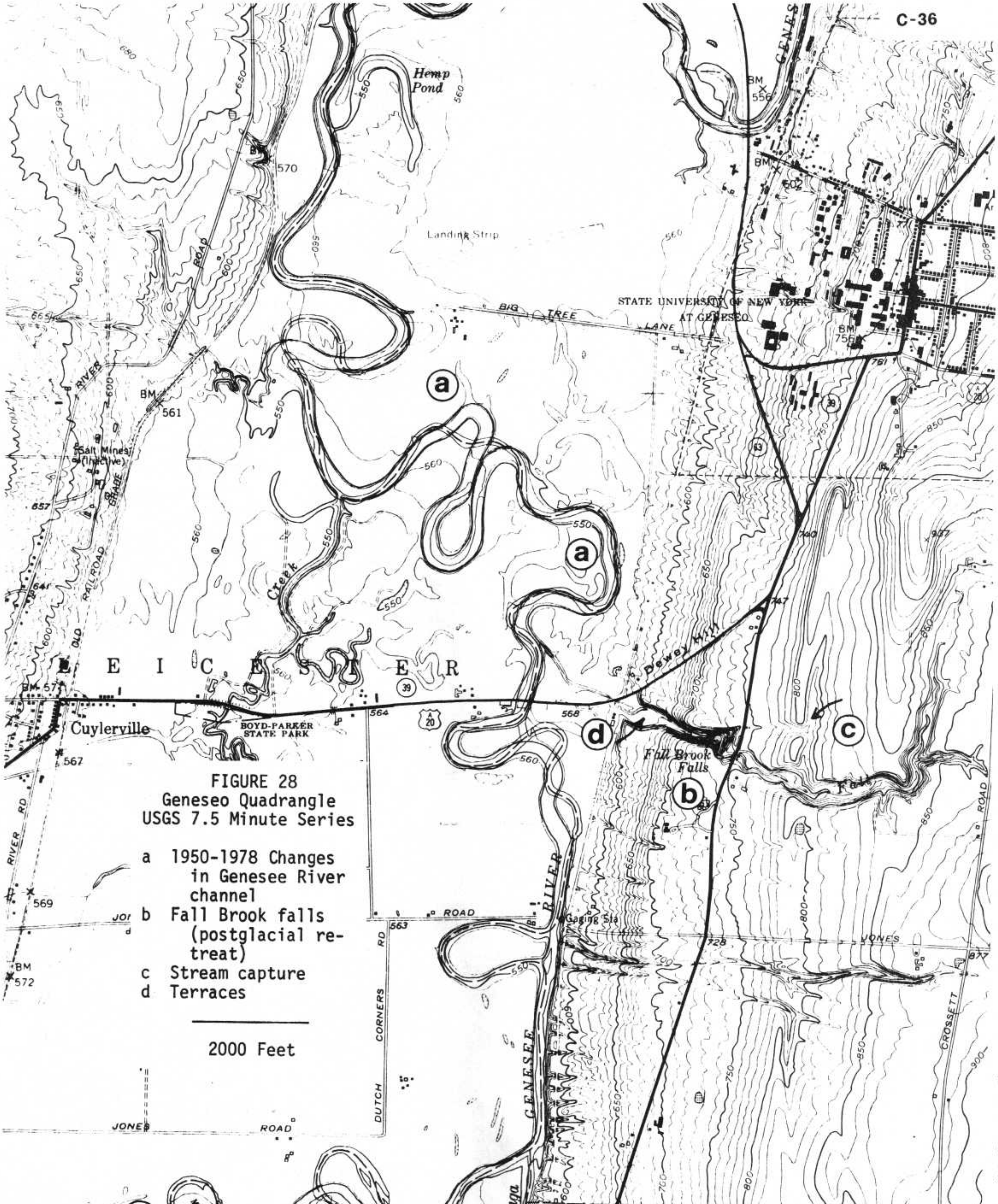

FIGURE 28
Geneseo Quadrangle
USGS 7.5 Minute Series

a 1950-1978 Changes in Genesee River channel
b Fall Brook falls (postglacial retreat)
c Stream capture
d Terraces

2000 Feet

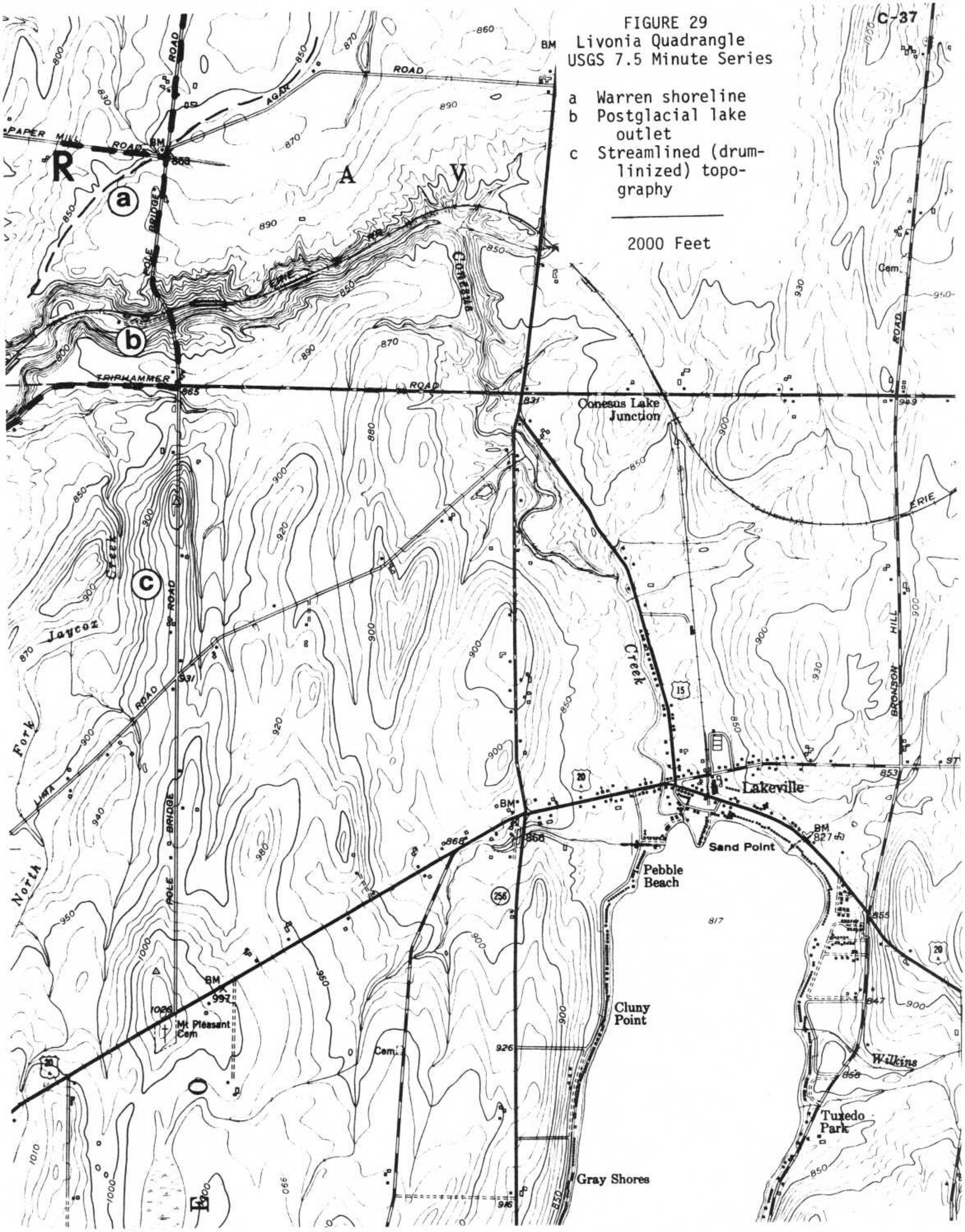

FIGURE 29
Livonia Quadrangle
USGS 7.5 Minute Series

a Warren shoreline
b Postglacial lake outlet
c Streamlined (drumlinized) topography

2000 Feet

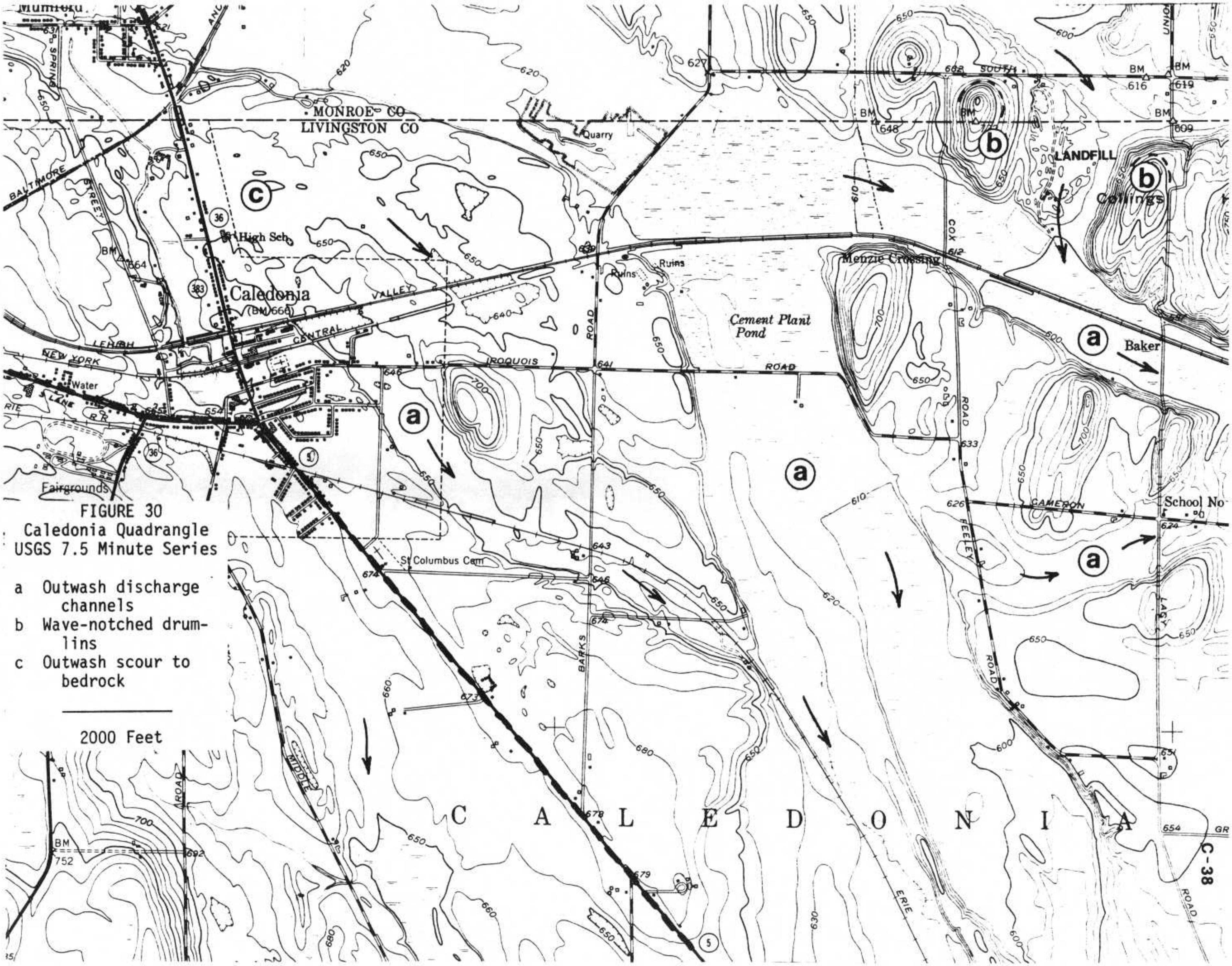

FIGURE 30
Caledonia Quadrangle
USGS 7.5 Minute Series

a Outwash discharge channels
b Wave-notched drumlins
c Outwash scour to bedrock

2000 Feet

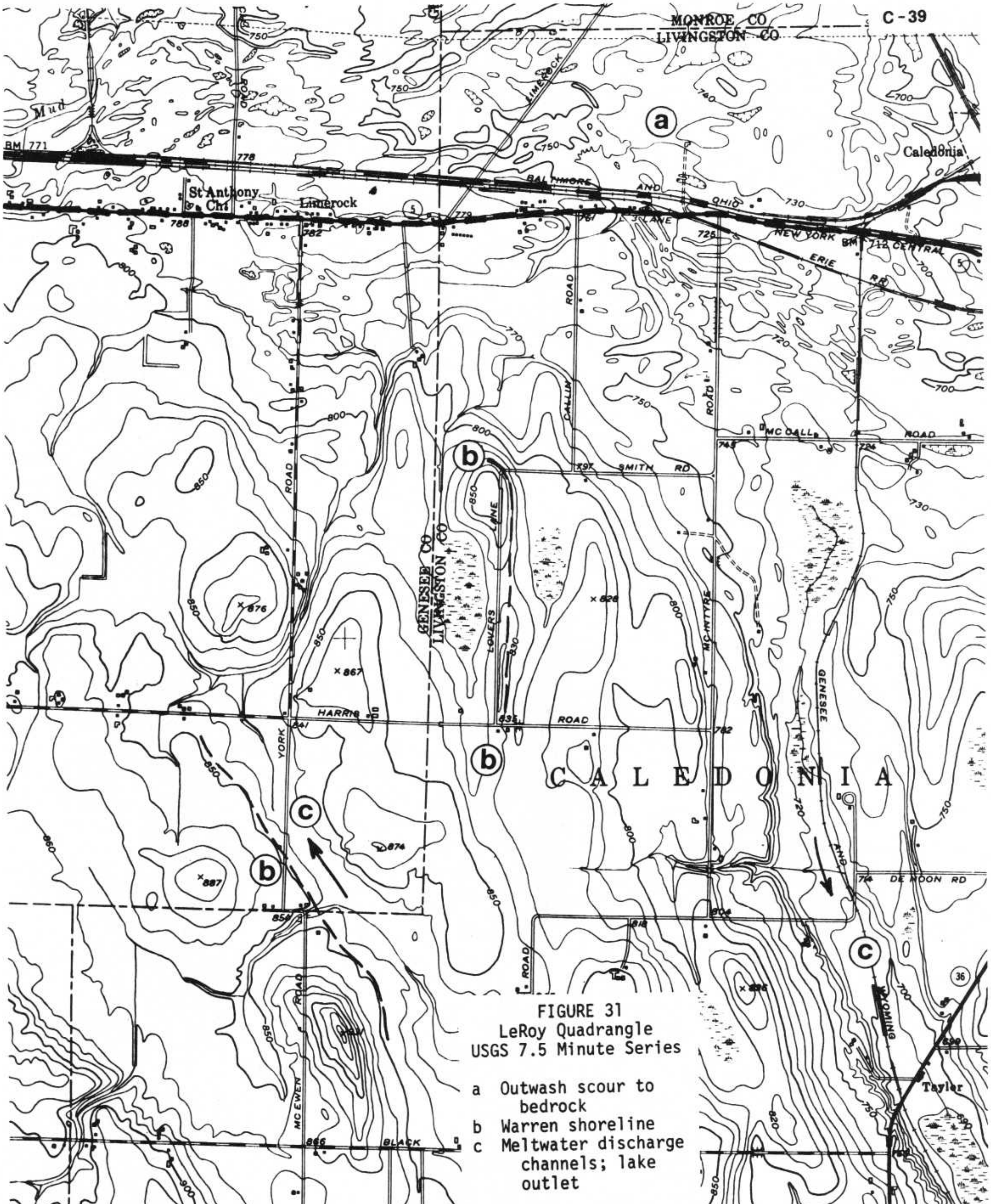

FIGURE 31
LeRoy Quadrangle
USGS 7.5 Minute Series

a Outwash scour to bedrock
b Warren shoreline
c Meltwater discharge channels; lake outlet

2000 Feet

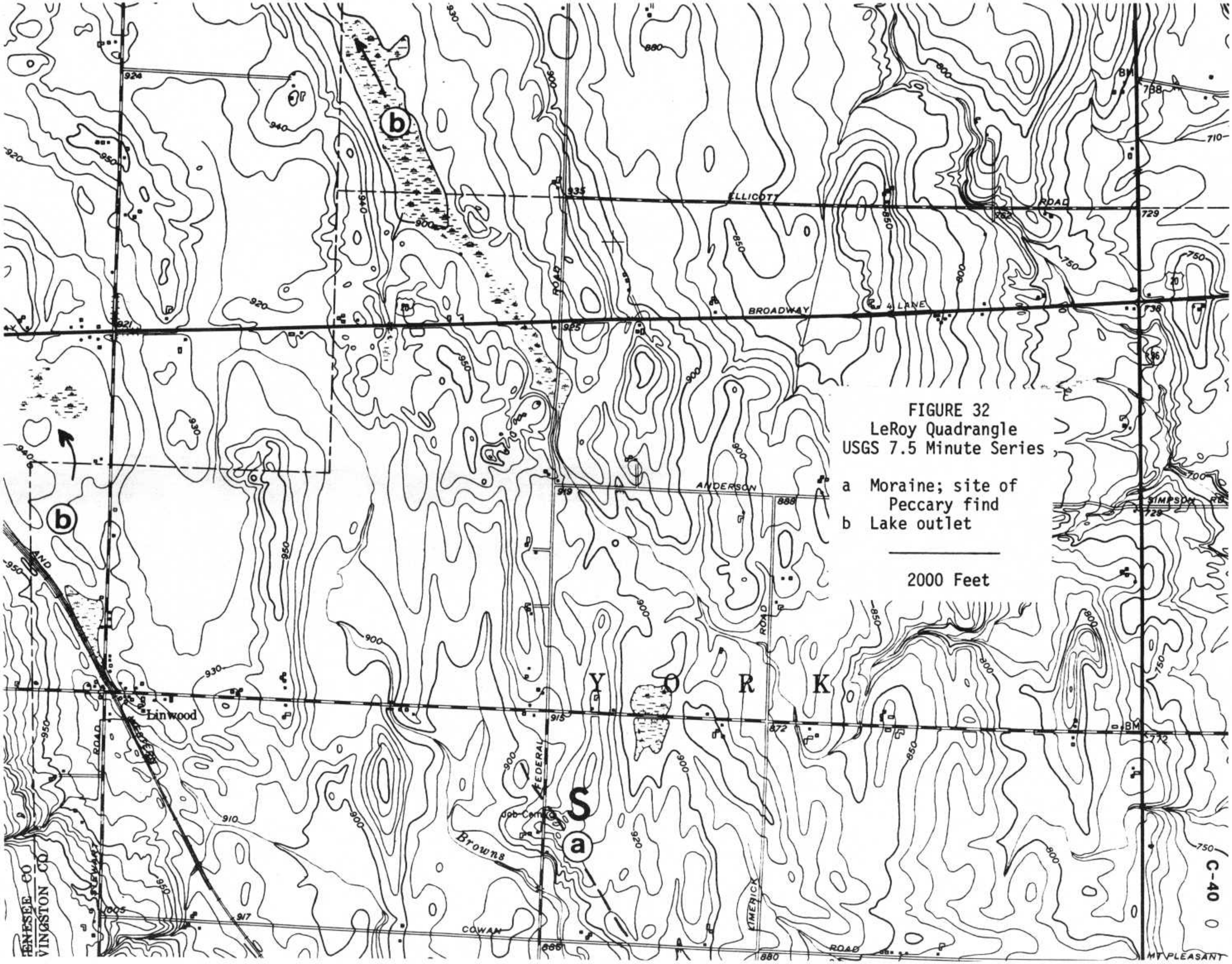

FIGURE 32
LeRoy Quadrangle
USGS 7.5 Minute Series

a Moraine; site of Peccary find
b Lake outlet

2000 Feet

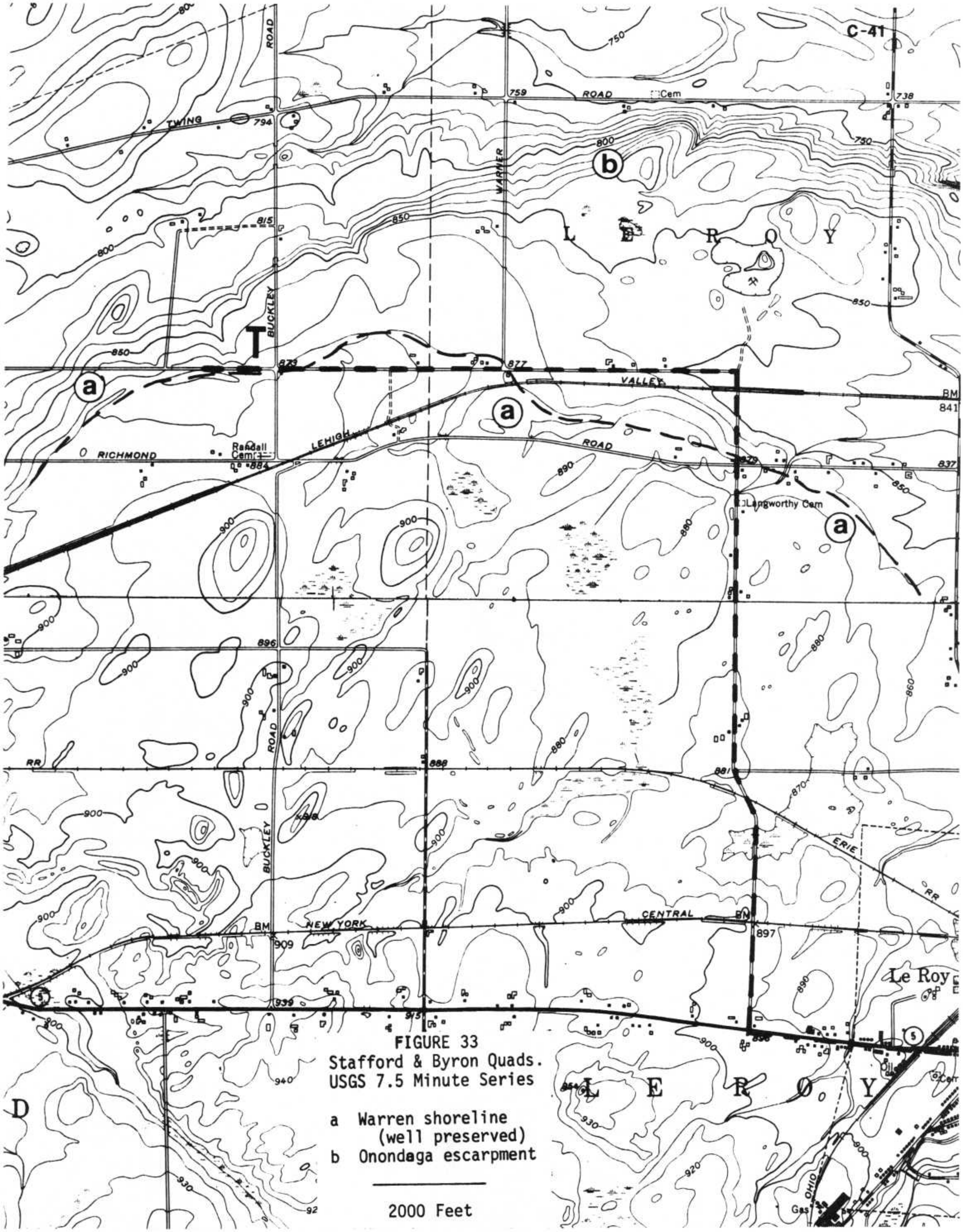

FIGURE 33
Stafford & Byron Quads.
USGS 7.5 Minute Series

a Warren shoreline (well preserved)
b Onondaga escarpment

2000 Feet